POZO RECIO

2808591265

Immediate acoustic effects of laryngeal manual therapy in a group of patients with muscle tension dysphonia using the laryngograph.

LETICIA TEBA DEL POZO RECIO

SEPTEMBER 2006

Submitted in partial fulfilment of the MSc in Speech and Language Sciences

Department of Human Communication Science
University College London

Contents

Page number

Abstract

Currently, the National Health Service, as well as The Royal College of Speech and Language Therapists, places a great deal of emphasis on treatments which have a strong evidence base. However, although the last two decades have witnessed an increase in research in voice therapy, there is still a lack of efficacy studies in treatments for voice disorders, particularly inorganic disorders such as muscle tension dysphonia. There are two main confounding issues in efficacy research in voice therapy. One is the eclectic use of criteria to measure change which has made it difficult to standardize outcomes; the other is the lack of studies using objective means to measure outcomes.

This pilot study aims to build on existing studies done on the efficacy of laryngeal manual therapy as a treatment for muscle tension dysphonia, and to pilot more extensive studies in the area. The study focused on immediate changes captured objectively using instrumental equipment: the laryngograph. The laryngograph captures physical changes in the vocal apparatus through measuring acoustic features which are associated with aspects of voice.

The voices of ten subjects diagnosed with muscle tension dysphonia were recorded and analysed by the laryngograph immediately before and after a session of laryngeal manual therapy by an expert clinician. Although statistical analysis did not show significant change due to the small size of the group, individual results suggest most subjects experienced change and improvement in acoustic parameters associated with pitch and voice quality.

Acknowledgements

I would like to thank the staff of the Speech and Language Therapy Department at the Royal National Throat, Nose and Ear Hospital where the data for this project was collected; in particular, Ruth Epstein for her clinical supervision and guidance, as well as her overall support. I am very grateful to Lesley Mathieson who carried out the treatment, and for providing her knowledge and advice. I also greatly appreciate Evelyn Abberton's expert knowledge and advice in analyzing the acoustic data, and Jane Maxim and Anne Edmundson's academic support.

List of Tables

Appendices

Introduction

Current treatment of voice disorders

In the past, approaches to treating non-organic voice disorders such as muscle tension dysphonia fell within the remit of speech therapists, unlike some organic voice disorders, which tended to involve professionals of other domains such as medicine. The move toward a multi-disciplinary approach to all voice disorders has allowed for therapy principles from different disciplines to be shared, and has made it possible to identify how dysfunction in one area of the vocal apparatus can produce failure in another. (Lieberman in Harris, Harris, Rubin & Howard, 2000). The evolving environment of the voice clinic requires greater sophistication in diagnosis, treatment and documenting clinical effect (Behrman & Orlikoff, 1997).

Review of the Literature

Muscle tension dysphonia (MTD)

Musculoskeletal tension "plays a major role in the development and maintenance of (hyperfunctional) dysphonia" (Roy & Leeper, 1993:322) and can exist as a primary or secondary factor (Mathieson, 2001; Lieberman in Harris et al., 2000; Roy, Bless & Ford, 1996; Aronson, 1990). Muscle tension dysphonia is a group of hyperfunctional non-organic voice disorders, characterised by excessive effort in phonation, and if left untreated can result in changes to the vocal fold mucosa. Other terms for this disorder are used in the literature, such as *psychogenic dysphonia* (Aronson, 1990), *functional dysphonia* (Boone, Macfarlane & Von Berg, 2005) or *vocal misuse* (Colton & Casper, 1996; Mathieson, 2001).

Descriptions and definitions of muscle tension dysphonia vary. However, recurrent features are the presence of laryngeal tension, the source of which is attributed to a variety of factors (Roy et al., 1996). The multi-factorial nature of the aetiology of MTD can be a confounding factor in reaching an accurate diagnosis. Roy et al. (1996) describe four sources of excessive muscle activity: psychological and/or personality factors that induce tension; technical misuses of the vocal mechanism in the context of extraordinary voice demands; learned adaptations following an upper respiratory tract infection, and compensation for underlying disease. Individuals in "high-risk" professions such as teachers, actors, singers and telesales people (Verdolini & Ramig, 1998) are more susceptible to the damaging vocal behaviours above.

Additional factors may impact upon vocal fold vibration and, as a result, further compromise the efficacy of voice production by placing strain on other structures (such as intrinsic and extrinsic laryngeal muscles) in order to compensate (Colton & Casper, 1996). Examples of these are: irritation of the vocal folds caused by gastric reflux or external irritants; the balance of fluid in the mucosa of the vocal folds which can be affected by factors; such as hormones (e.g. the contraceptive pill), diuretics and drying agents in medication to name a few (Colton & Casper, 1996).

Symptoms and signs of muscle tension dysphonia:

A clinician will reach a diagnosis by evaluating the patient's description of symptoms, and by observing or testing information of perceptual, acoustic and physiological characteristics of their voice (Colton & Casper, 1996). A thorough case history reveals vocal misuse and/or abuse, relevant information about the patient's emotional well-being and stress surrounding the onset of the problem (Aronson, 1990), as well as providing an opportunity for the voice therapist to observe voice quality and interpret the individual's description of their sensory symptoms (Mathieson, 1993; 2001).

Sensory and perceptual symptoms:

The individual suffering from muscle tension dysphonia will often complain of sensory symptoms. Descriptions of musculoskeletal tension are often described with adjectives such as, "aching", "constriction" and "tightness", predominantly around the neck and shoulders (Mathieson, 1993; 2001; Roy et al., 1996). Sensory descriptions associated with other features of MTD are: a constant need to clear the throat which is associated with increased secretion; a sore, burning throat and/or a tickling sensation which is associated with inflammation (Mathieson, 1993); most patients confirm these symptoms are aggravated when tired, stressed, shouting or speaking for long periods of time (Roy et al., 1996). Patients may also perceive changes in their voice quality and some report sounding strangled and pressed, and others report breathiness. They may also complain of abnormalities in pitch such as an excessively high or low pitch and/or pitch breaks (Mathieson, 2001). These symptoms not only limit the speakers' ability to communicate efficiently but also cause a great deal of emotional distress (Mathieson, 1993; 2001). It is not uncommon to find patients adopting strategies to compensate for their decreased vocal function, which in turn can exacerbate the problem and result in causing further stress to the vocal tract.

Perceptual-auditory signs:

The clinician may observe signs indicating a speaker may have MTD. Mathieson (2001) describes the main vocal features as a result of muscle tension dysphonia in relation to the abnormal physiological functioning of structures. A vocal pitch deemed inappropriate for the speaker by an experienced clinician is often a sign of a problem and is a feature of MTD. An abnormally high pitch is produced by stiffened vocal fold tissues causing hyper-adducted vocal folds and therefore disturbs their vibratory pattern by increasing the vocal fundamental frequency, a high-held larynx contributes to this behaviour (Colton & Casper, 1996). An abnormally low pitch can be caused by increased mass of the vocal folds and/or the approximation of the ventricular vocal folds, the latter can also give the voice a hoarse and dipolophonic quality (Colton et al., 1996; Mathieson, 2001). MTD often results in a change in the patient's voice quality, typical features are: hoarseness, breathiness, hard glottal attack and pitch breaks.

Acoustic signs:

Auditory perceptions are essential in diagnosing MTD, however, they cannot provide all the information necessary about the underlying mechanisms at work and can often be misleading (Behrman & Orlikoff, 1997). Although instrumentation is not used in all voice clinics, they can provide information about the dysphonic voice as a disturbance to the physiology of the vocal folds will result in acoustic changes (Colton & Casper, 1996). Hirano (1981) suggests using the following acoustic parameters to assess vocal function: fundamental frequency, amplitude of the acoustic waveform, the amount of spectral harmonics and amount of noise and we would expect these features to reflect a hyperfunctional voice.

Change in pitch, the perceptual correlate of fundamental frequency (Baken, 1987), is an important symptom of a disordered voice. The vocal folds usually vibrate at 100-300 Hz during normal conversation (Hirano, 1981) however, as mentioned above, this can become faster or slower in patients with MTD, resulting in an abnormally high or low pitch respectively. Aronson's (1990) suggestion that abnormal pitch in functional disorders is due to laryngeal muscle tension is supported by findings in Roy and Hendarto's study (2004). Periodicity of the vocal waveform may also be irregular due to an inability to maintain a steady balance between the mechanisms of the vocal folds in relation to the force of air. Acoustic analysis may show minimal variations in fundamental frequency, which reflects a narrowed pitch range and a decreased ability to produce a signal at higher frequencies. Amplitude may also decrease and noise to harmonics ratio may increase (Mathieson, 1993; Hirano, 1981).

<u>Observable physiological signs:</u>

In early stages of MTD where organic changes such as polyps have not occurred, laryngoscopic examination will show a normal larynx as "the dysphonia is a reflection of disordered vocal tract function at the glottic and supraglottic levels" (Mathieson, 2001, p. 160). However, the following physiological signs may be present: anteroposterior laryngeal squeezing and excessive medial compression (Colton & Casper, 1996), reduced vocal fold vibration and mucosal wave, a prolonged closed phase if vocal folds are hyperadducted or a prolonged open phase if there is a glottal chink (Mathieson, 2001). Stroboscopic examination gives information regarding the open to close ratio of the vibratory cycle, which may be disproportionate in patients with MTD. A shorter open phase and longer closed phase is characteristic where there is a great deal of tension and is associated with perceived hoarseness; a longer open phase and shorter closed phase is associated with excessive breathiness in the voice (Mathieson, 2001).

Palpation of the larynx may reveal excessive extralaryngeal tension that is not visible. Mathieson (2001) gives a detailed account of the structures most susceptible to tension and how this compromises their ability to function and that of related structures. Key signs are: tension in the sternocleidomastoid muscles; the distal points of the hyoid bone are sensitive to pressure; the floor of the oral cavity will be firm to touch; a reduction in space between the they thyroid and cricoid cartilage; the larynx is resistant to lateral digital pressure and the larynx may rise dramatically on phonation may be felt, and the larynx may be held excessively high or low (Mathieson 2001).

Treatment for muscle tension dysphonia

Overall management takes into account the impact of a voice disorder on the whole patient's life, which cannot be underestimated, for example, the ability to carry out employment can be affected and the individual's self-image (Verdolini & Ramig, 1998). Alongside the specific requirements relevant to the patient, clinicians use a combination of the following classification of approaches in different proportions in their management plan: *education and explanation; vocal tract care and conservation* including vocal hygiene*; direct treatment approaches,* including improved vocal techniques; pedagogic strategies; facilitating techniques and *indirect treatments* such as psychological counselling, relaxation techniques and specialized techniques such the Alexander method (RCSLT, 2005; Mathieson, 2001).

Treatment for muscle tension dysphonia, like for most voice disorders, involves various strategies which address both aetiological factors where possible, and symptomatic factors (Mathieson, 2001). There is a wide range of traditional treatment approaches used in clinics to remediate MTD. This section will give concise examples of specific methods, some have been proven successful by efficacy studies and others are popular although their effectiveness may not have been proven (Mathieson, 2001; Pannbacker, 1999; Ramig & Verdolini, 1998).

<u>Examples of direct treatment approaches which have proved effective for MTD are:</u>

Voice modification:

- Working on soft vocal onset by introducing voicing after /h/ to prevent hard glottal attack.

- Pitch modification: Speaking at the either extreme of one's pitch range is effortful and contributes to tension. Although it is now widely acknowledged that there is no 'optimum pitch' at which an individual should speak, changing pitch can improve vocal quality and loudness, and pitch glides can extend the individual's range. (Mathieson, 2001; Boone et al., 2005)

Pedagogic:

- The Accent method was developed by Svend Smith in the 1930's. This aims to increase flexibility of the vocal folds working on first on breathing exercises, and then combining these with voice exercises to rhythmic beating and whole body movement in rhythmic sequences. A study by Fex et al. (1994) showed good outcomes for patients with dysphonia using this method. (Mathieson, 2001)

Facilitative:

- The yawn/sigh uses a vegetative yawn to relax pharyngeal constrictors and maximize the space in the supraglottal airway, encouraging gentle phonation on the outward sigh can relax the laryngeal muscles as well as producing an improved voice. (Mathieson, 2001; Boone et al., 2005, Colton & Casper, 1996).

Aronson (1990) suggests that although all treatment for vocal hyperfunction has the same aim of taking the work out of speaking, manual therapy achieves this in a shorter period of time.

Laryngeal manual therapy as a treatment for MTD

The discipline of manual therapy aims to remediate the dysfunction of joints and muscles caused by a patient's habitual muscle use or posture. Laryngeal manual therapy applies this principle to the larynx, and addresses vocal dysfunction from a physiological aspect by examining and treating the musculoskeletal system (joints, ligaments, muscles and surrounding soft tissue) in relation to its ability to carry out the highly complex movements required for effective voice production (Lieberman in Harris, Harris, Rubin & Howard, 2000). Musculoskeletal tension is usually present in non-organic voice disorders (Aronson, 1990) and manual therapy is a relatively new technique used to treat this (Mathieson, 2001).

There are a number of descriptions for the procedure of manual therapy in the literature; Aronson (1990) (Appendix I), Mathieson (2001) (Appendix II), and Lieberman (1998) who describes an osteopath's procedure. The procedure described by Mathieson (2001) will be used in this study. This procedure is carried out in a calm environment with the clinician either standing behind the patient or sitting in front. The clinician kneads the laryngeal musculature and adjusts the position of the larynx; the emphasis is usually on lowering the larynx, which tends to be high-held due to excessive effort phonation (Mathieson, 2001). The intensity of the massage begins at a superficial level and is adapted according to the resistance encountered and how well the patient tolerates it (Roy, Ford & Bless, 1996).

<u>Rationale:</u>

Efficient laryngeal functioning relies on the performance of all individual muscles and the interaction between them during phonation, which is negatively affected by excessive tension in the intrinsic and extrinsic laryngeal muscles and causes discomfort (Mathieson, 2001). Manual therapy addresses this in order to retrieve the patient's optimum voice and alleviate discomfort and pain by releasing the normal voice suppressed by excess muscular tension by mechanically and/or psychologically releasing tension (Aronson, 1991). An example of an area vulnerable to tension in dysphonic patients is the hyoid bone and its muscular attachments, tension in the thyrohyoid muscles results in chronic shortening of these and causes pain or discomfort as well as raising the vocal pitch (Lieberman in Harris et al., 2000). Lieberman states that, "Clinical observations show that manipulation of these muscles not only reduces pain and discomfort, but also drops the vocal pitch and increases resonance" (Lieberman in Harris et al., 2000 p. 97).

Lieberman suggests that a 'cure' after one session of LMT is likely to be an "emotionally-based" response on the part of the patient (Lieberman in Harris et al. 2000, p. 126). However, a number of studies have shown significant improvements after manual therapy in both perceptual and acoustic parameters, and overall symptoms of MTD even after one session (Roy & Leeper, 1993; Roy 1994; Roy, Bless & Ford 1996; Roy, Bless, Heisey & Ford, 1997; Van de Lierde, De Ley, Clement, de Bodt and Van Cauwenberge, 2004). Mathieson (2001) states that there can be a dramatic improvement in the voice of a patient with MTD's even after 10 or 15 minutes and that some patients report that discomfort has been alleviated.

Efficacy studies of laryngeal manual therapy

From 1993 to 2005, six studies were carried out on the efficacy of manual therapy as a treatment for a range of voice disorders, all of which indicated this to be a beneficial treatment.

Findings from Roy and Leeper's (1993) study investigating the immediate effects of LMT (as described by Aronson, 1990) for 17 subjects presenting with functional dysphonia using both acoustic and perceptual (4 clinically certified listeners) measures. The findings showed that for the majority of patients, measures of jitter, shimmer and signal to noise ratio improved in both connected speech and for sustained vowels. These acoustic aspects are important in MTD as discussed earlier. Remarkably, the majority made significant changes towards a "normal" voice after just one session. The study identifies limiting factors such as the small number of subjects used, the reliance on subjective data and the ambiguity of whether improvement may be due to factors unrelated to the treatment. They state that within this client group, aetiologies differed and muscle tension played varied roles (Roy & Leeper 1993:248), which in turn affects the patient's response to this treatment.

These findings were reinforced by Roy's study (1994) of a single case on the effects of manual therapy as treatment for a patient with ventricular dysphonia following long-term endotracheal intubation who presented with laryngeal rigidity and discomfort in addition to hoarseness. Eight sessions over two months resulted in perceptual and acoustic improvements; dramatic perceptual improvements were noted after the first session.

Roy, Bless, Heisey and Ford (1996) extended Roy & Leeper's study (1993) by including long-term effects of manual therapy for functional dysphonia. Perceptual and acoustic outcome measures were used before and after treatment, and again after a three month period. In addition, subjects were interviewed. Overall, the findings confirm that manual therapy had beneficial results for patients with functional disorders particularly with regards to short-term effects. The authors again suggest that manual therapy be used as a part of management of functional dysphonia as long term results were less robust which they suggest may be in part due the unpredictable effects of the varying aetiologies within this disorder group (1993).

Roy, Ford and Bless' study (1997) evaluated the role of manual therapy as a diagnostic and management tool, focusing on two voice disorders associated with musculoskeletal tension; muscle tension dysphonia and spasmodic dysphonia. They concluded that manual therapy helps in ensuring proper diagnosis and can avoid unnecessary surgical or medical intervention as well as providing information on how best to manage these two disorders.

Van Lierde, De Ley, Clement, de Bodt and Van Cauwenberge (2004) studied four Dutch professional voice users with moderate to severe vocal hyperfunction received 25 sessions of laryngeal manual therapy at least once but mostly twice a week. They assessed participants one week before and one week after the block of therapy using objective (aerodynamic, voice range, acoustic and Dysphonia Severity Index) and subjective methods (videolaryngostroboscopic and auditory perceptual evaluation) to measure change. The results showed improvements in all cases, in addition, they found that "the improvement of the acoustic results…as measured by means of an objective approach are in agreement with the perceived improvement of strain, hoarseness, and the overall grade of the pathology" (Van Lierde et al. 2004, p. 412). In addition, this study suggests that there is a faster vocal recovery time using LMT with professional voice users which the authors suggest might be due to their familiarity of the workings of this area of their body and ability to maximize on proprioceptive feedback.

Roy and Hendarto's study (2005) used LMT with patients diagnosed with functional dysphonia to study the role of pitch in the disordered voice as this is a treatment that does not directly target pitch. Although as a group there was no significant change in speaking fundamental frequency after therapy, 80% of the subjects experienced a change in vocal pitch, which was greater than one semitone. They state that abnormal pitch in functional disorders is due to imbalance in laryngeal muscle tension and therefore, pitch change can occur by using manual therapy which addresses this.

Evaluating outcomes

Effectiveness of treatments in healthcare provision has become increasingly important and is emphasized in the 2005 NHS health service strategy document (www.nhsdirect.nhs.uk) as well as in RCSLT clinical guidelines (2005). The lack of efficacy research of treatment in voice therapy and the use of techniques that are "popular" rather than "proven" (Pannbacker, 1999) is a theme throughout the literature on voice (Mathieson, 2001; Carding, 2000; Behrman & Orlikoff, 1997; Olswang in Frattali, 1996). Pannbacker (1999) partly attributes this to the inconsistency around outcome measures used and the methods of reporting results. The literature indicates the need to rectify the failings of efficacy studies which have failed to use objective or reliable methods to collect data (Verdolini & Ramig, 1998; Carding, 2000; Roy and Leeper, 1993) and the overall lack of empirical data as an evidence base for voice treatment (Carding, 2000, Roy and Leeper, 1993; Pannbacker, 1999; Behrman & Orlikoff, 1997).

The laryngograph as an outcome measure

Electroglottography (EGG) is an electrical, instrumental method of examining vocal fold phonatory vibration. Two electrodes are placed on either side of the thyroid cartilage, which record the electrical signal created by vocal fold contact (Fourcin, 2000). The laryngograph (Laryngograph Ltd.) is a device which records the EGG signal; the output is in the form of a waveform called the Lx signal from which the vocal fold fundamental frequency can be ascertained (Mathieson, 2001). Reliability of data collected using the laryngograph can be compromised by the following: incorrect placement of the electrodes; the Lx signal from some women and children can be difficult to obtain as their larynges are usually smaller (Mathieson 2001); absent or diminished signal in certain individuals e.g. patients with unilateral paralysis; patients with thick or large necks (Mathieson, 2001). However, the laryngograph has the advantage of being non-invasive and not obstructing the production of speech. The Lx waveform can give information about aspects of voice quality such as fundamental frequency, vocal fold frequency distributions, amplitude and closed phase ratio distributions in the speaker's voice (Fourcin, McGlashan, Blowes, 2000). The laryngograph is particularly useful for observing vocal fold contact patterns shown by the changed relationship between closed and open phases of the vibratory cycle (Carlson & Miller, 1998); these measurements can be used as a baseline against which to measure change.

The debate around the use of objective versus subjective outcome measures for research and clinical purposes in voice therapy is mentioned in a great deal of the literature (Carding, 2000; Mathieson, 2001; Pannbacker, 1999; Hirano, 1990; Behrman & Orlikoff, 1999; Verdolini & Ramig, 1998). The use of the term 'objective' is often synonymous with the use of instrumentation (Carding, 2000) and this interpretation will be used in this study. Auditory and perceptual measures are essential in measuring voice, particularly when considering the importance placed on evaluating holistic effects of voice disorders and outcomes on patient's quality of life (Mathieson, 2001; World Health Organization, 1980). However, there is a strong case for incorporating instrumentation in the assessment and management of voice disorders (Behrman & Orlikoff, 1997). Using instrumentation provides reliability, for example, using fundamental frequency as an accurate measure of pitch as 'listeners' judgements of pitch have often been unreliable (Baken, 1987). It also provides quantitative information and allows testing to be accurately replicated as well as contributing to the need for measures of as many vocal facets as possible in order to gain a better understanding of voice production (Berry, Epstein, Freeman, MacCurtain & Noscoe, 1982; Carding, 2000); although there is an element of subjectivity in the interpretation of 'objective' methods (Behrman & Orlikoff, 1997; Carding, 2000).

Aims and hypotheses of this study

Previous studies have shown that laryngeal manual therapy produces improvements after one session in patients with functional dysphonia, using a variety of outcome measures. However, most literature stresses the need for more evidence about voice therapy outcomes to be collected using objective measures. This study is a pilot study to test immediate effects of manual therapy and documents changes using objective rather than subjective means. It explores whether laryngeal manual therapy results in changes/improvement in acoustic data after one session, and if so, whether there is an overall trend in the changes across the ten participants.

Hypothesis:

Physical measures will change for patients with MTD after one session of manual therapy and there will be similarity in the changes across participants. Patients with MTD will show improvements in aspects of voice after one session of manual therapy. The criteria for improvement will be the amount and direction of change across the following parameters:

- Frequency range will increase and mean speaking fundamental frequency will be closer to the appropriate norm and less irregular
- Physical measures correlating to quality of voice will improve, e.g. higher ratio of open to closed phase of vocal folds per vocal cycle (excessive breathiness) will be reduced; higher ratio of closed phase per cycle (excessive pressed quality) will be reduced; less variability in open to closed phase per cycle.

Method

Design

The participants acted as their own controls in a repeated measure, within subject design.

Participants

Ten participants for the study were selected as a sample from patients who were diagnosed with mild to moderate muscle tension dysphonia at a weekly voice clinic. Diagnosis was made by the same ENT consultant for each_subject, using video-strobo laryngoscopy. The participants each fulfilled a specific set of criteria (Table 1).

Table 1: Criteria for participants

Exclusion criteria	Inclusion criteria
▪ Smokers	▪ NAD larynx (apart from soft pre-nodular swelling)
▪ Psychiatric history	
▪ Respiratory disease (including asthma)	▪ MTD diagnosis
▪ Neck problems	
▪ Hypertension/cardiovascular problems	
▪ Frail elderly	
▪ Children (18 years +)	
▪ Neuropathology	
▪ Non-treatable reflux	
▪ Thyroid masses	
▪ Head/neck malignancy	
▪ Previous voice therapy	

Additional information reported by the clinician and the patient about the patients' symptoms and diagnosis were taken from medical notes written by the diagnosing ENT consultant and speech and language therapist.

There were eight women and two men in the study sample, a gender balance which reflects the higher incidence of dysphonia amongst women (Mathieson, 2001). Ages ranged from 19 to 50 (Table 2), the mean age being_29.5 years. Professions included singing, acting and teaching (Table 3), a reflection of the predominance of these professionals in groups of MTD patients (Mathieson, 2001).

Table 2: Individual participant information

Subject	Gender-	Age (yrs)	Occupation	Additional information to MTD Diagnosis*	Patient reported
LM01	F	45	Singer/teacher	Larynx held slightly tight	Tightness, burning, muscle pain around back and neck
LM02	F	24	Singer/telesales	High-held larynx; Superior peri-laryngeal muscles tightly held	Voice tires; loses voice; unable to sing and loss of vocal range.
LM03	M	32	Teacher	Not available	Voice loss; rough voice; tightness and choking; tightness and pain in muscles on the side of neck
LM04	F	29	Teacher	Not available	Dryness, unpredictable clarity of voice
LM05	F	21	Trainee accountant	Not available	Dry, creaky voice; tightness; difficulty being understood
LM06	F	19	Singer	Musculoskeletal tension; mild dysphonia	Sore, dry, tickling throat
LM07	F	25	Trainee actress; ballerina	Tightly held larynx; cricothyroid tightly held; tongue base tightly held	Child-like, weak voice; soreness
LM08	M	28	Student; singer	Mild to moderate dysphonia	Voice loss; unable to sing; unpredictable voice quality
LM09	F	50	Housewife	Mild dysphonia; intermittent hoarseness	Hoarse, sore voice; tickling and aching in throat
LM10	F	22	Actress and dancer in musical theatre	Mild tension in neck and moderate dysphonia	Voice loss; reduced pitch range; lower pitch in speaking voice; tense neck and has to strain to produce voice

Table 3: Descriptive statistics for participant ages

Descriptive statistics	Sample (N=10)
Mean age (years)	29.5
Standard deviation	10.32
Range	19-50

Materials/Equipment

- Reading 'Arthur the Rat' (Appendix III)
- Laryngograph Processor with various sizes of adjustable neck bands (Laryngograph Ltd, London)
- Speech Studio Software (Laryngograph Ltd, London)
- Headset microphone

Procedure

For all subjects, assessment took place according to the protocol at the Royal National Throat, Nose and Ear Hospital as part of their routine diagnostic appointment. Assessment and diagnosis was made by the same ENT consultant for each patient; manual therapy was carried out by the same experienced clinician for each patient; the recordings were made by the author for each patient.

Treatment and the before and after recording procedure was repeated in identical conditions for each person, and took place in one session which lasted between one hour and 45 minutes to two hours. Manual therapy lasted half an hour on each occasion.

The participants were informed about the study and gave consent to participate, after which the author carried out the recordings in a silent room. The data was recorded using an electrolaryngograph and a microphone. The Speech Studio software was used for anaylsis. The headset microphone was positioned to the left and 10cm away from the patient's mouth; the neck band was placed appropriately with the electrodes on either side of the larynx (Dejonckere, 2000). The equipment was tested by asking the participants to count from one to five while the author checked the Lx signal. Participants were asked to read 'Arthur the Rat' in their normal speaking voice without changing their voice for direct speech of characters in the story.

The participants were than taken to the clinician who was also given their diagnostic information who carried out the manual therapy procedure as described by Mathieson (2000), (Appendix II). After this, the recording procedure was repeated by the author.

Data Analysis

Voice measurements:

This study looks at the efficacy of manual therapy in terms of the functioning of the underlying mechanisms of the vocal apparatus, not only perceptual and sensory signs and signals. In addition, reading a passage aloud rather than production of sustained vowels was used in order to capture natural features while speaking; each require different levels of sampling accuracy and the laryngograph is specifically designed for connected speech (Fourcin et al., 2002). For these reasons, and because this equipment is routinely used at the clinic in question, the laryngograph was chosen as a method for capturing these features and their corresponding changes in response to treatment. The laryngograph, in combination with the Speech Studio Software, provides a tool to manipulate the EGG waveform in order to analyze physiological functioning during phonation. (Behrman & Orlikoff, 1997).

The two-minute reading, "Arthur the Rat", (Appendix III) was chosen in order to provide a connected speech sample. The laryngograph was used to analyze aspects related to pitch and quality of voice for connected speech (Fourcin, 2000, Speech Studio User's Guide) and the following parameters where chosen for these purposes:

<u>For pitch range and regularity</u>: DFx1&2 (Fx gives the trace for frequency, the physical correlate for pitch); CFx provides a graphical and numerical indicator of pitch irregularity.

<u>For an indication of voice quality</u>: vocal fold closed phase range and regularity is measured (Qx is a measure of the closed phase); QxFx1&2 (dynamic contact) gives the range of closed phase values across the speaker's pitch range; DQx1&2 provides information of the range and regularity of the closed phase in each vocal fold cycle; CQx gives a graphical and numerical indicator of irregularity of closed phase quotient and control (Speech Studio User's Guide, p. 24-27). For a more detailed explanation of these parameters, see Appendix IV.

Normative data

The traces captured in cross-plots were interpreted qualitatively using recommendations from Speech Studio User's Guide (Appendix IV) and the literature (Fourcin, 2000; Fourcin et al., 2002) to provide an estimate of normality. Visual analysis of crossplots was analyzed. "The presence of voice pathology will be associated with marked discrepancies in magnitude and shape between these two forms of representation." (Fourcin et al, 2002). Examples of cross-plots for "normal" voices are provided in Appendix V.

Quantitative data was also analysed. However, normative data for the numerical values of the above parameters is not provided by Laryngograph Ltd., therefore, criteria for numerical values were applied in the following manner. The results of mean speaking fundamental frequency were compared with normative values taken from Carding (2000) which are taken from values for American males (mean 112.5 Hz, range of means 84-151 Hz) and American females (mean 192.4 Hz, range of means 168-221Hz) in the absence of normative data for British English speakers. The results for percentage irregularity of pitch were interpreted using "theoretically founded criterion" from Fourcin et al. (2002) stating that pitch deviations more than 6% away from the line arise from variability other than intonation; and also bearing in mind that expert clinician's find that variation up to 10% can be found in "normal" voices.

The numerical values taken from closed phase quotient (Qx) were compared within participants before and after treatment and analyzed on the basis of whether there was change, and actual change was interpreted according to individual improvement.

Results

The pre- and post- therapy quantitative data and the data shown by the cross-plots for each parameter were analyzed for each participant. The data was then compared descriptively across participants to identify if there were changes after treatment, and if so, trends in changes both across the group and individually. The data was also considered in the context of data available for 'normal' American speakers which corresponded to each participant as described in the data analysis section.

In this section, the results of the experiment will be presented in two parts:

Part I: A description of overall quantitative group results

Part II: A description of each individual participants results, presented in the following format:

- a printout of before treatment data
- a printout of after treatment data
- a table describing the data printouts of the individual
- a brief interpretation of the individual's results

Part I. Quantitative group results

The following terminology, taken from the Speech Studio User's Manual (Laryngograph Ltd), will continue to be used in order to describe the quantitative parameters as they appear on the raw data:

<u>i) For frequency range, mean speaking fundamental frequency and regularity:</u>

DFx1&2: Speaking fundamental frequency (SFo)

CFx: Irregularity of vocal fold vibration (pitch irregularity)

<u>ii) For physical correlates for quality and control of voice:</u>

QxFx1&2(dynamic contact): range of closed phase values across frequency range

DQx1&2: closed phase quotient

CQx: irregularity of closed quotient phases

Table 4 (below) gives quantitative data for the parameters measured by the laryngograph for each participant before and after therapy. The data for subject LM04 was found to be unreliable and has been excluded from the following results. However, the same statistical analyses that were carried out which included including the unreliable data and are shown in Appendix VI.

Table 4: Quantitative data for four acoustic parameters measured by the laryngograph, before and after manual therapy for patients with muscle tension dysphonia

Subject	Gender	Pre-DQx1&2 (Hz)	Post-DQx1&2 (Hz)	Pre-CFx %	Post-CFx %	Pre-mean DQx1&2 %	Post-mean DQx1&2 %	Pre-CQx %	Post-CQx %
LM01	F	177.15	187.69	8.43	7.27	46.5	45.5	42.78	23.69
LM02	F	187.69	187.69	2.03	[illegible]	46.5	43.5	21.92	69.46
LM03	M	114.87	114.87	13.95	12.14	53.5	54.5	29.27	28.56
LM04	*F*	*172.11*	[illegible]	*15.22*	[illegible]	*49.5*	*59.5*	*27.59*	*73.81*
LM05	F	210.67	210.67	5.54	10.23	45.5	46.5	5.54	31.63
LM06	F	204.68	216.85	8.09	5.55	43.5	48.5	26.99	20.73
LM07	F	182.34	182.34	8.87	8.36	41.5	46.5	33.9	23.40
LM08	M	136.6	[illegible]	14.84	10.77	47.5	49.5	39.01	34.17
LM09	F	182.34	198.85	13.86	33.41	51.5	53.5	50.85	55.1
(LM10)	F	167.21	172.11	37.72	30.2	52.5	54.5	69.44	65.52
Summary means SD**		173.73 (30.75)	179.08 (32.84)	12.59 (10.32)	15.60 (10.71)	47.61 (4.10)	49.17 (4.12)	35.52 (18.20)	39.14 (19.00)

*data in red indicates a change away from normative data for speaking fundamental frequency (Carding 2000) and for CFx % (Fourcin et al. 2002).
***LM04 is not included in summary means (Appendix VI)*

Changes and trends across the group

<u>i) Frequency range, mean speaking fundamental frequency and regularity.</u>

Figures for mean speaking fundamental frequency for five out of nine participants has increased; for four it has stayed the same; it has not decreased for any participants. Changes were on a relatively small scale for the five subjects, the smallest increase being 4Hz and the largest 16Hz. Post-therapy figures that changed for mean speaking fundamental frequency have moved closer to their corresponding normative data (Carding 2000), except for one male (LM08). Summary means of SFo for the whole group rose. Inferential statistics show that change for this parameter over time is significant (see Table 6). Irregularity of fundamental frequency has reduced for five out of nine participants and for four it has increased, for two of these it has increased dramatically (LM02, LM09). Means for this figure across the group rose by 3-4%.

Across the group, the frequency range (shown by 90% fundamental frequency range values on DFx1&2 cross-plots and in Table 5) has widened for seven out of nine participants, for one of those it has increased dramatically (182 Hz); for only two subjects it has decreased. The figures in the column labelled 'amount of change in Hz' shows that pitch range has widened for the majority of participants.

Table 5: 90% frequency range in Hz before and after laryngeal manual therapy in patients with muscle tension dysphonia (acoustic indicator associated with perceptually perceived pitch range)

Subject	Before	After	Amount of change in Hz
LM01	148.8 to 222.6	143.3 to 275.1	58
LM02	167.4 to 223.2	108.1 to 263.3	99.4
LM03	93.7 to 149.5	92.7 to 146.4	-2.1
(LM04)	*83.5 to 244.5*	*56.4 to 288.5*	*71.1*
LM05	187.2 to 247.1	184.1 to 252.8	8.8
LM06	176.1 to 257.5	175.8 to 287.5	30.3
LM07	129.1 to 259.0	131.3 to 264.8	3.6
LM08	77.2 to 216.1	79.0 to 221.3	3.4
LM09	106.4 to 249.2	142.5 to 467.3	182
LM10	41.3 to 287.4	46.9 to 282.4	-10.6
Summary means* **SD**	109.38 (62.59)	150.76 (83.60)	

-Red indicates decrease in frequency range after therapy

**LM04 data not included*

A within-subjects ANOVA was carried out to test the statistical significance of changes in the pitch range over time. The inferential statistics (Table 6) showed that change over time is not statistically significant ($p = 0.086$, $f(1, 9) = 3.84$). It was noted that when the data for LM04 was included, inferential statistics showed pitch range is significantly greater post-therapy; $p=0.45$. (Appendix VI).

<u>ii) Physical correlates for quality and control of voice</u>

These features are better represented by the DQx1&2 and CQx cross-plots and will be described and discussed for each participant in the following section.

The before and after results of the closed phase quotient (DQx1&2) in Table 4 shows very little change across subjects. For two, the percentage has decreased showing vocal folds were closed for less time within each cycle; for seven, the figure has increased. Again, inferential statistics showed change is not significant over time for this parameter (see Table 6). Post-therapy change for CQx results showed that for over 3 out of 9 subjects there was 19% change, one figure increased by 49%, 5 subjects showed a change of between 1 to 6%, and 1 changed by 10% (see Table 4). Change is not statistically significant (see Table 6).

Statistical Analyses

1. Independent variable: Time

A repeated measures ANOVA was carried out in order to ascertain the statistical significance of treatment effects with time as the independent variable, the four parameters (SFo, pitch irregularity, closed phase quotient, irregularity of closed phases) are the dependent variables.

Table 6: Effects of treatment over time (excluding data for subject LM04)

	(mean) Time pre	SD	(mean) Time post	SD	F (1,8)	P
SFo	173.73	(30.75)	179.076	(32.84)	6.548	0.034
Pitch irregularity	12.59	(10.32)	15.60	(10.71)	0.861	0.380
Closed phase quotient	47.61	(4.10)	49.17	(4.12)	3.336	0.105
Closed quotient irregularity	35.52	(18.20)	39.14	(19.00)	0.278	0.613

The results in Table 6 show that there is no significance of effects over time for all parameters as significance is shown by $p<0.05$. The contact quotient figure is close to being significant ($p=0.064$). However, with a sample size this small it is unlikely that effects will be found.

2. Independent variable: Gender

A between subjects repeated measures ANOVA was carried out to find if there is an effect of gender.

Table 7: Descriptive statistics: means for male and females for each parameter (excluding data for subject LM04)

	Males	S.D	Females	S.D
Pre-SFo	125.74	(15.37)	187.44	(15.30)
Post-SFo	127.74	(18.20)	193.74	(15.90)
Pitch irregularity	14.40	0.63	12.07	(11.86)
	11.46	0.97	17.24	(10.32)
Closed phase quotient	50.50	4.24	46.79	(3.98)
	52.0	3.54	48.36	(4.14)
Closed quotient irregularity	34.14	6.89	35.92	(20.80)
	31.37	3.97	45.36	(21.28)

Table 8: Inferential statistics for repeated measures for time and gender (excluding data for subject LM04)

	Time		Gender		Time x Gender	
	F (1,8)	P	F (1,8)	P	F (1,8)	P
SFo	2.630	0.149	26.54	0.01	0.704	0.429
Pitch irregularity	0.64	0.81	0.051	0.828	0.848	0.388
Closed phase quotient	1.97	0.203	1.454	0.267	0.001	0.975
Closed quotient irregularity	0.024	0.882	0.202	0.667	0.224	0.651

Table 8 shows that there is a gender effect for mean fundamental frequency (SFo) (p=0.01), mean speaking fundamental frequency for females is higher than for males (see Table 7). This is expected as this feature tends to differ between men and women. There are no effects of gender on any other parameters when analyses are carried out for nine, as well as for ten participants. There are no interaction effects, therefore, treatment is not affected by gender. This is also true when the data for LM04 is included (see Appendix VI).

Conclusion

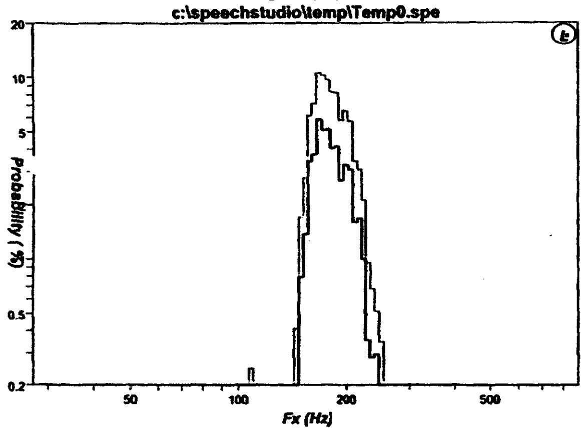
The statistical analyses do not support the hypothesis that there is change after therapy as a result of treatment. However, observation of the data does reveal changes and some trends in those changes. It is interesting to note that before carrying out recordings post-treatment, the author documented verbal reports from participants regarding perceived outcome after treatment; all ten reported improvement of perceptual symptoms.

Part II. A description of individual participant results, presented in the following format:

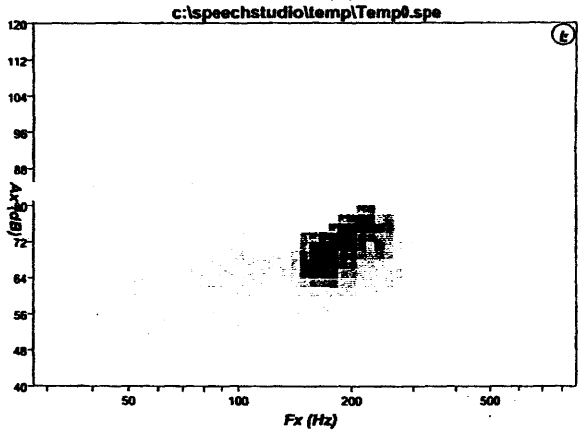
- **a printout of before treatment data**
- **a printout of after treatment data**
- **a table describing the data printouts of the individual**
- **a brief interpretation of the individual's results**

LMO1 PRE

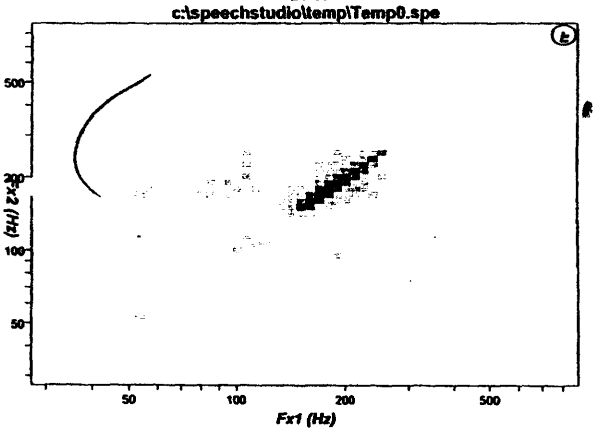
DFx1&2
c:\speechstudio\temp\Temp0.spe



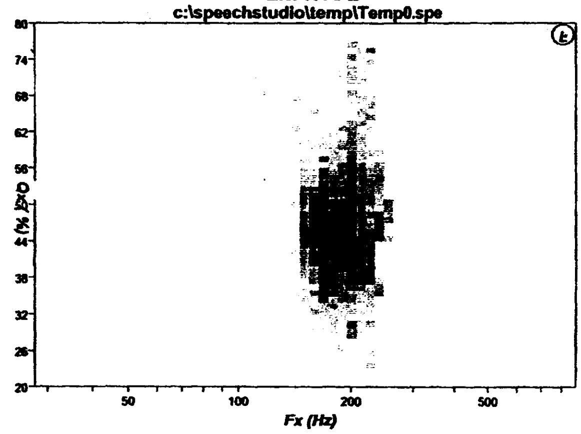
VRP1&2
c:\speechstudio\temp\Temp0.spe



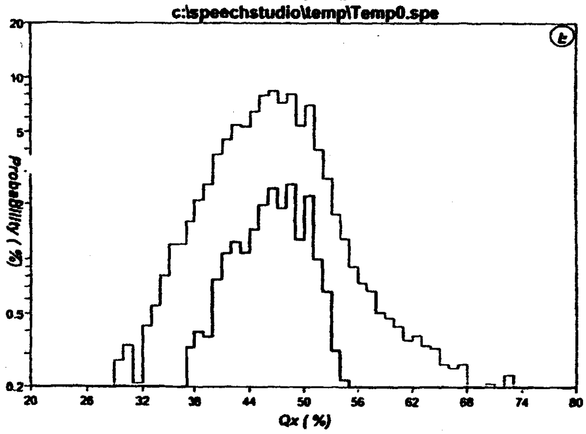
CFx
c:\speechstudio\temp\Temp0.spe



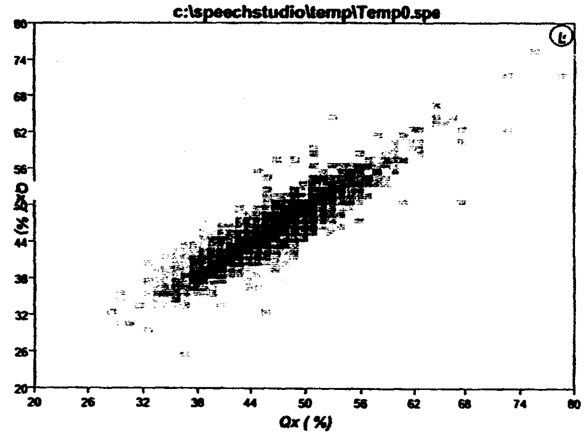
QxFx1&2
c:\speechstudio\temp\Temp0.spe



DQx1&2
c:\speechstudio\temp\Temp0.spe

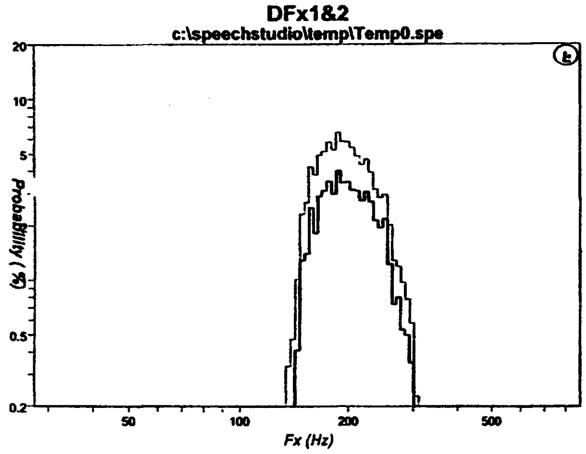


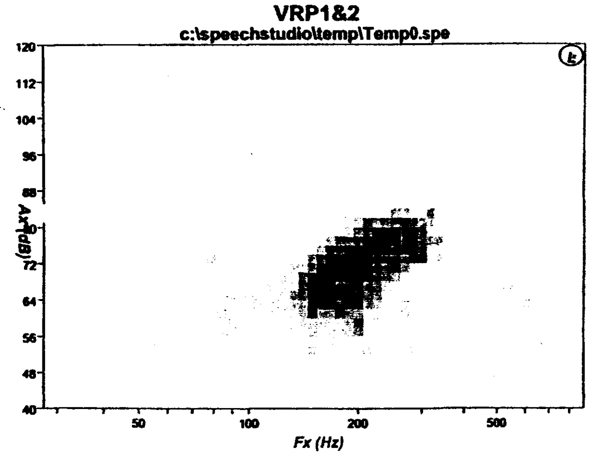
CQx
c:\speechstudio\temp\Temp0.spe

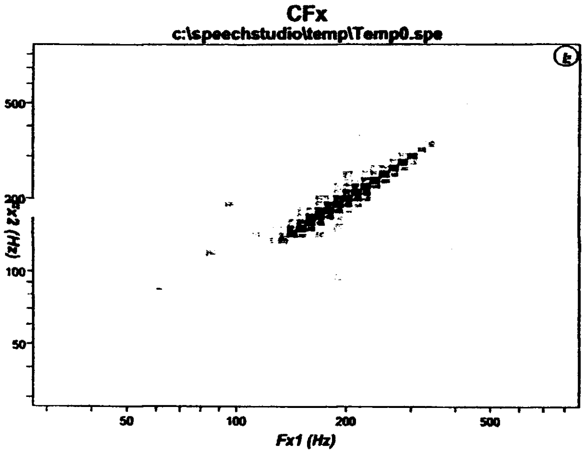


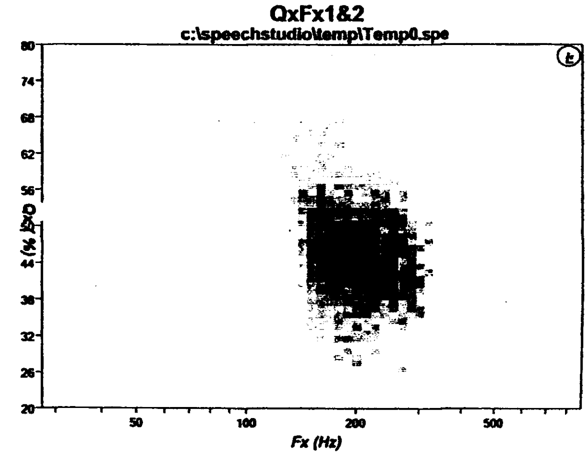
Graph	Samples	<>	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	8897	0, 0	177.15Hz	167.21Hz	178.25Hz	72.56	156.5, 211.9Hz	148.8, 222.6Hz	
VRP1&2	8893	4, 0							
CFx	8446	0, 0							8.43%
QxFx1&2	8623	236, 38							
DQx1&2	8623	236, 38	46.50 %	46.50 %	46.48 %	7.14	39.2, 53.5 %	36.3, 58.9 %	
CQx	8203	89, 43							42.78%

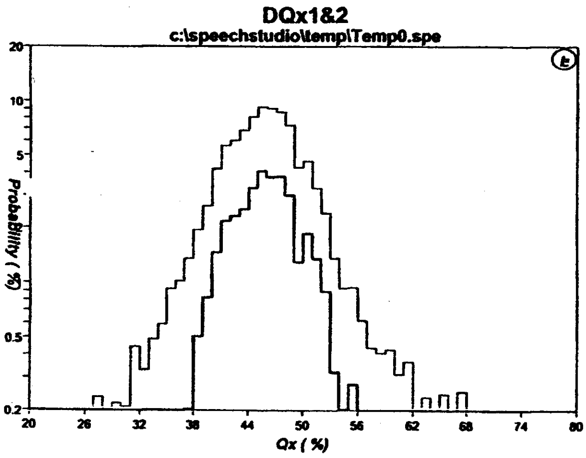
LM01 POST

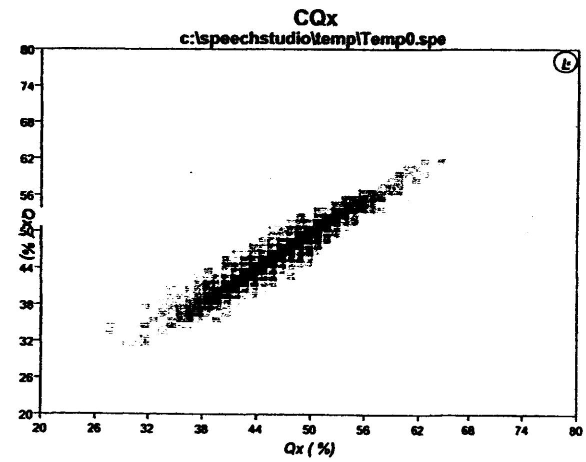












Graph	Samples	<>	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	12188	0, 0	187.69Hz	187.69Hz	193.51Hz	93.89	154.1, 252.3Hz	143.3, 275.1Hz	
VRP1&2	12113	75, 0							
CFx	11374	0, 0							7.27%
QxFx1&2	11427	700, 61							
DQx1&2	11427	700, 61	45.50 %	45.50 %	45.83 %	6.66	39.5, 52.4 %	36.7, 56.5 %	
CQx	10781	84, 49							23.69%

Table 9: Results for LM01 (female, 45 years, teacher & singer)

	Pre-LMT	Post-LMT
DFx1&2	• First and second order distributions are similar • Some low frequency distribution around 100Hz (very low probability so not significant) • Sfo: 177.15 • Narrow frequency range	• First and second order distributions similar • Sfo: 187.69 • Low frequency distribution not present • Wider frequency range
CFx	• Irregularity 8.43% • The diagonal line is shorter reflecting the shorter range in frequency. • More scatter around lower end of line	• Irregularity 7.27% • More compact and narrow • less scatter shows there is less irregularity
QxFx1&2	• Most of the time vocal folds are closed 44-50% • More scattered in her main frequency range (around 200 Hz)	• Less scattered so shows a more consistent pattern of close to open ratio of the vocal folds
DQx1&2	• Mean speaking closure quotient is 46.5%	• Mean speaking closure quotient is 45.5%
CQx	• The diagonal line is quite broad and scattered	• Compact diagonal line, little scatter

Interpretation:

Frequency range, mean speaking fundamental frequency and regularity:

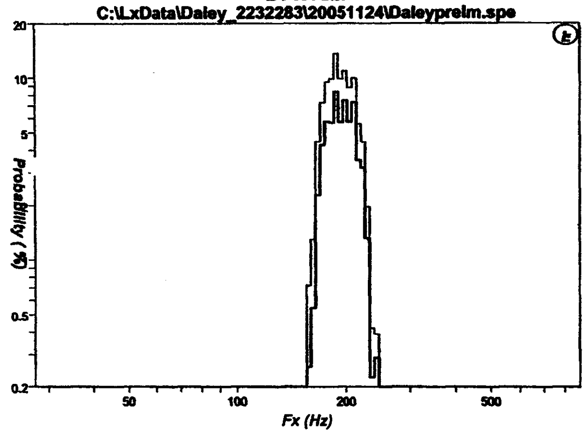
Before therapy the similar shapes of DFx1 and 2 show regularity in vocal fold vibration and therefore a well defined voice. However, the mean of 177.15 Hz is slightly low for a woman (Carding, 2000) and can be a symptom of MTD (Mathieson, 2001) so the increase post-therapy is an not of great concern, in addition, an increase in pitch has been noted as a side effect of LMT by Lieberman "in patients who habitually lower the larynx as it releases upwards in the neck" during manipulation (Lieberman in Harris et al., 2001:128). The presence of outlying irregularity pre therapy at around 100 Hz can indicate creak, however it is very low probability. Vocal fold vibration irregularity has decreased post therapy and the speaker's pitch range is wider shown by the longer CFx line as well as the numerical values for fundamental frequency range at 90%.

Physical correlates for quality and control of voice:

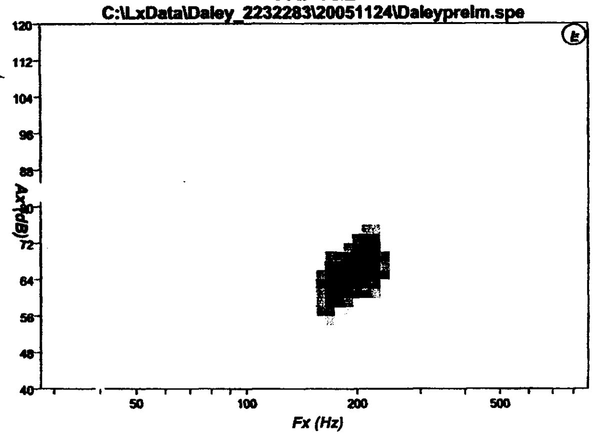
Before and after therapy, the closed phase lasted roughly half of the vocal fold cycle which is appropriate. The DQx plot shows that after therapy the distribution is more symmetrical and first and second distributions are similar reflecting better closed phase control and regularity. (Speech Studio User's Manual, Laryngograph Ltd.)

LH02 PRE

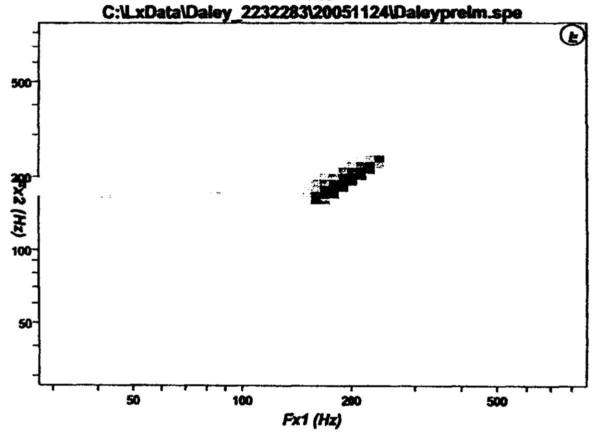
DFx1&2
C:\LxData\Daley_2232283\20051124\Daleyprelm.spe



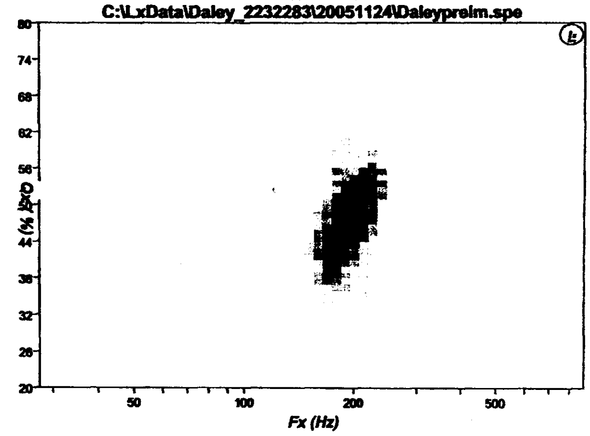
VRP1&2
C:\LxData\Daley_2232283\20051124\Daleyprelm.spe



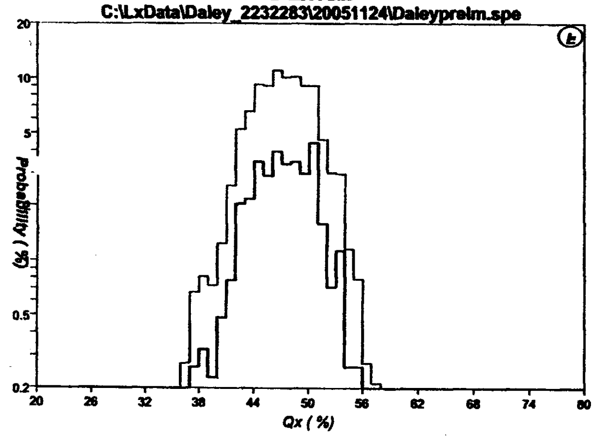
CFx
C:\LxData\Daley_2232283\20051124\Daleyprelm.spe



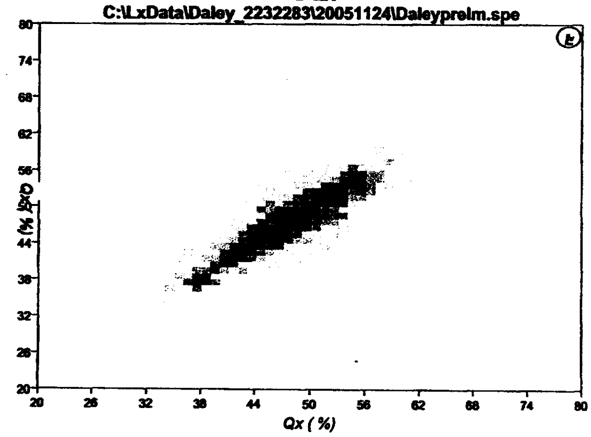
QxFx1&2
C:\LxData\Daley_2232283\20051124\Daleyprelm.spe



DQx1&2
C:\LxData\Daley_2232283\20051124\Daleyprelm.spe



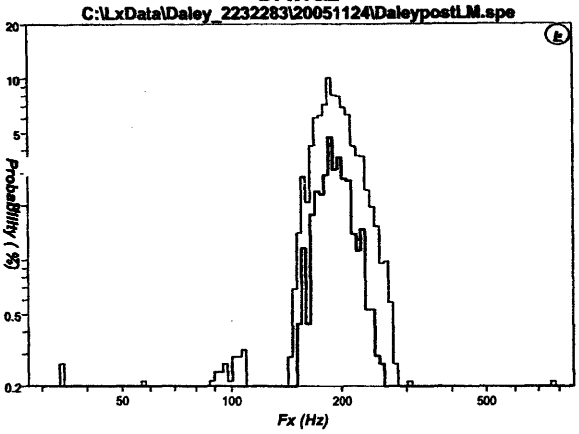
CQx
C:\LxData\Daley_2232283\20051124\Daleyprelm.spe



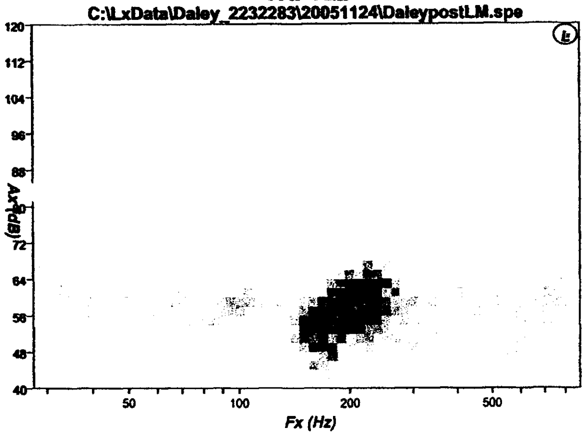
Graph	Samples	< >	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	3306	0, 0	187.69Hz	187.69Hz	191.80Hz	53.77	171.6, 216.9Hz	167.4, 223.2Hz	
VRP1&2	3306	0, 0							
CFx	3107	0, 0							2.03%
QxFx1&2	3286	19, 1							
DQx1&2	3286	19, 1	46.50 %	46.50 %	47.21 %	3.69	42.7, 51.7 %	41.4, 53.2 %	
CQx	3075	0, 2							21.92%

LM02 POST

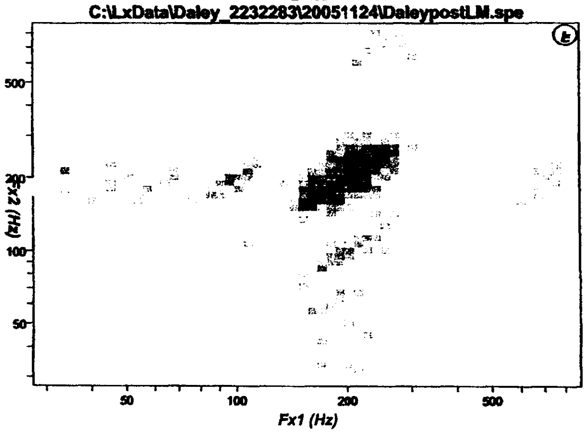
DFx1&2
C:\LxData\Daley_2232283\20051124\DaleypostLM.spe



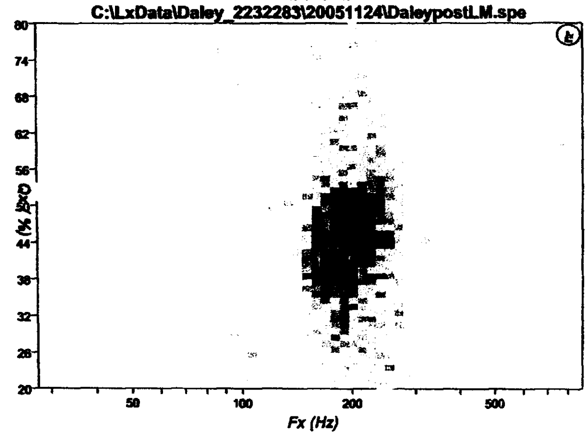
VRP1&2
C:\LxData\Daley_2232283\20051124\DaleypostLM.spe



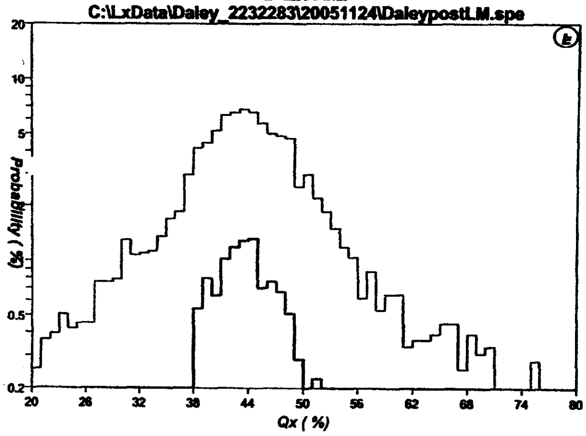
CFx
C:\LxData\Daley_2232283\20051124\DaleypostLM.spe



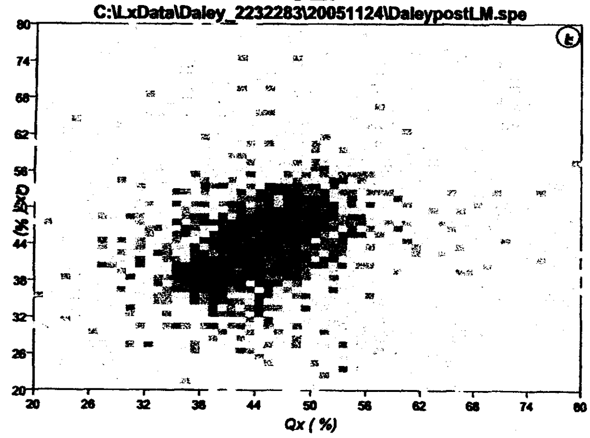
QxFx1&2
C:\LxData\Daley_2232283\20051124\DaleypostLM.spe



DQx1&2
C:\LxData\Daley_2232283\20051124\DaleypostLM.spe



CQx
C:\LxData\Daley_2232283\20051124\DaleypostLM.spe



Graph	Samples	< >	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	3757	0, 0	187.69Hz	187.69Hz	192.43Hz	101.41	158.1, 239.0Hz	108.1, 263.3Hz	
VRP1&2	3747	10, 0							
CFx	3368	0, 0							25.68%
QxFx1&2	3537	182, 38							
DQx1&2	3537	182, 38	43.50 %	43.50 %	43.83 %	9.18	34.2, 54.8 %	29.8, 62.0 %	
CQx	3045	67, 66							69.46%

Table 10: Results for LM02 (female; 19 years; singer & telesales)

	Pre-LMT	Post-LMT
DFx1&2	• First and second order distributions are similar shape and size • Sfo: 187.69 Hz • Narrow range of frequency 170-225 Hz • 90% range: 167.4, 223.2 Hz	• First order and second order distributions not as close1st and 2nd order shape similar, 2nd order smaller • Some low frequency distribution around 90-110Hz • Sfo: 187.69 Hz • Frequency range widened slightly to 150-250Hz • 90% range: 108.1, 263.3 Hz
CFx	• 2.03% irregularity	• 25.68% irregularity • broader line and more scatter in both low and high frequencies reflects greater irregularity • longer line reflects increased range
QxFx1&2	• main concentration of high closed phase ratio voicing is at lower part of her range	• spread out rather than a contained shape shows greater variability in ratio of closed to open phase
DQx1&2	• mean speaking closure quotient 46.5%	• mean speaking closure quotient 43.5%
CQx	• 21.92% • diagonal line, compact in lower frequencies	• 69.46% • extensive scatter in low and high frequencies shows a lot of irregularity and variability in closed phase

Interpretation:

Frequency range, mean speaking fundamental frequency and regularity:

The narrow frequency range on the Fx axis reflects reduced pitch range pre therapy which increases slightly after therapy which is an improvement. However, other aspects show deterioration. In DFx1&2, the first and second order plots are less similar in size and shape after therapy showing increased roughness. In addition there are outlying irregularities in the lower frequencies indicating greater pitch irregularity after therapy. The CFx crossplot shows increased irregularity of vocal fold vibration the percentage increase and the broad diagonal line with two lines on either side.

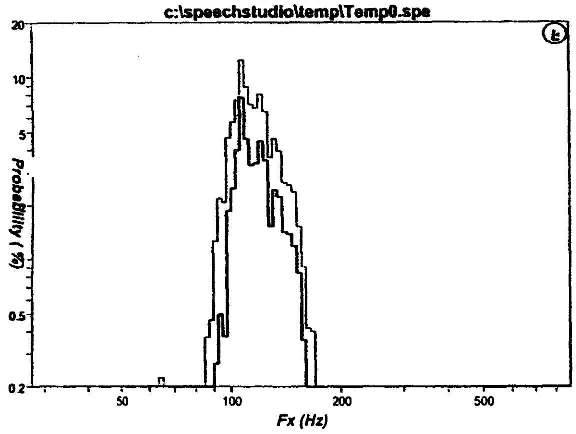
Physical correlates for quality and control of voice:

Post-therapy results of parameters related to voice quality show the speaker has deviated away from normal voice (see Appendix V for normal crossplots). The decreased percentage of closed phase quotient, increased irregularity of closed phase (CFx) and the scattered shape in the QxFx1&2 plot which can be reflective of instability of functional ability of closure of the vocal folds (Fourcin, 2000) strongly suggest an increase in features associated with a breathy voice. The DQx1&2 presents a lowered percentage of vocal fold closure (from 46.5% to 43.5%) within each cycle which represents a lengthened open phase, again reflecting breathiness in the speaker's voice and also a lack of control in this aspect of the voice as the shape is not contained but spread out. This is consistent with observations of the participant's voice made by herself, and the tester, after therapy. The participant reported feeling very "relaxed" and "less tight" around her neck area.

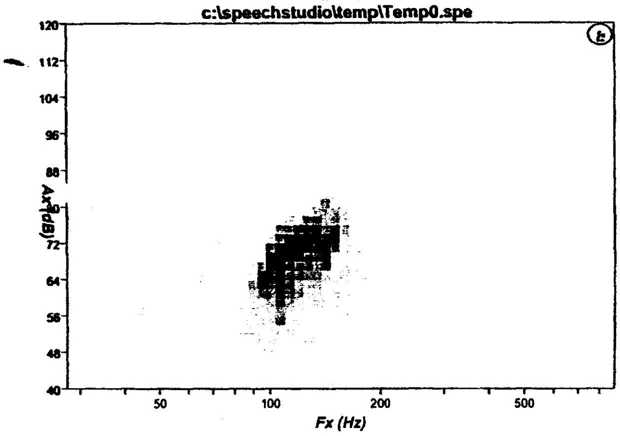
Overall, this participant's results show a deviation away from the norm as there is increased irregularity in vocal fold vibration and in closed to open ratio of vocal folds although her pitch range increases and speaking fundamental frequency stays the same.

LM03 PRE

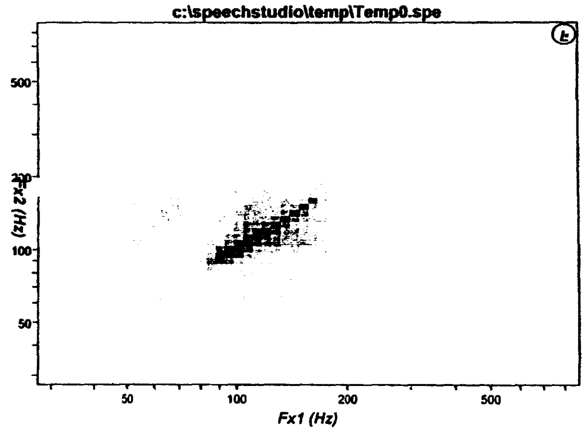
DFx1&2
c:\speechstudio\temp\Temp0.spe



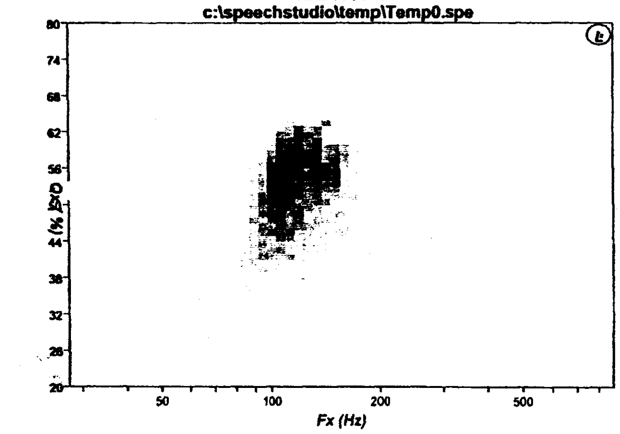
VRP1&2
c:\speechstudio\temp\Temp0.spe



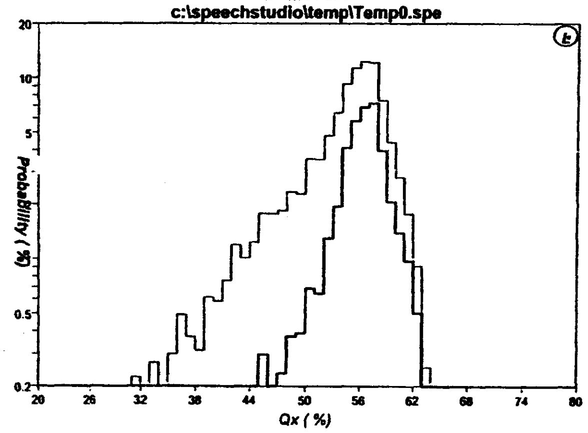
CFx
c:\speechstudio\temp\Temp0.spe



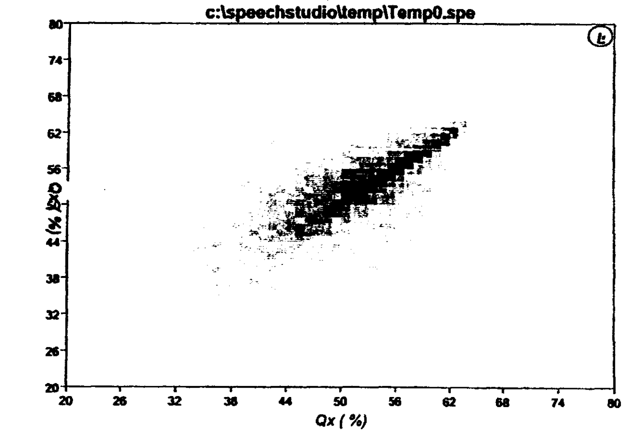
QxFx1&2
c:\speechstudio\temp\Temp0.spe



DQx1&2
c:\speechstudio\temp\Temp0.spe

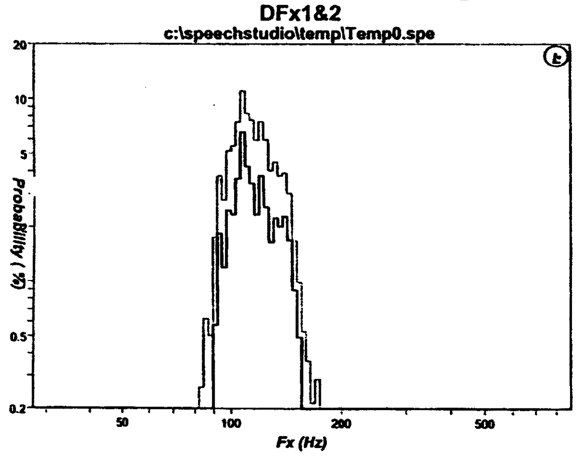


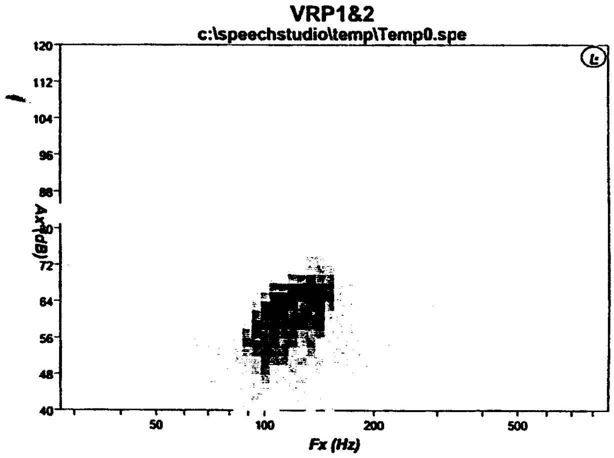
CQx
c:\speechstudio\temp\Temp0.spe

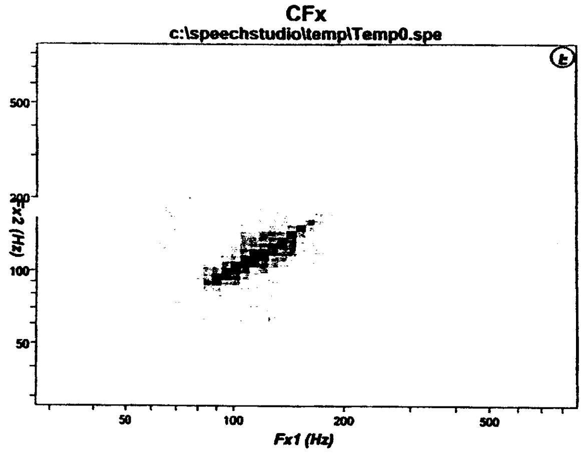


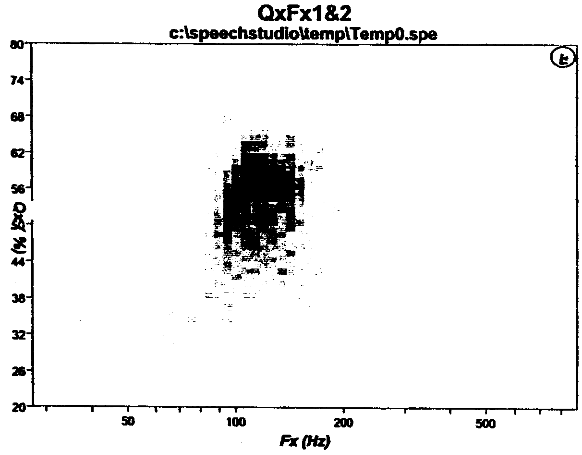
Graph	Samples	<>	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	6685	0, 0	114.87Hz	108.42Hz	114.40Hz	62.64	99.0, 141.2Hz	93.7, 149.5Hz	
VRP1&2	6684	1, 0							
CFx	6381	0, 0							13.95%
QxFx1&2	6663	20, 2							
DQx1&2	6663	20, 2	53.50 %	56.50 %	55.34 %	5.97	45.8, 59.1 %	41.9, 60.3 %	
CQx	6354	13, 2							29.27%

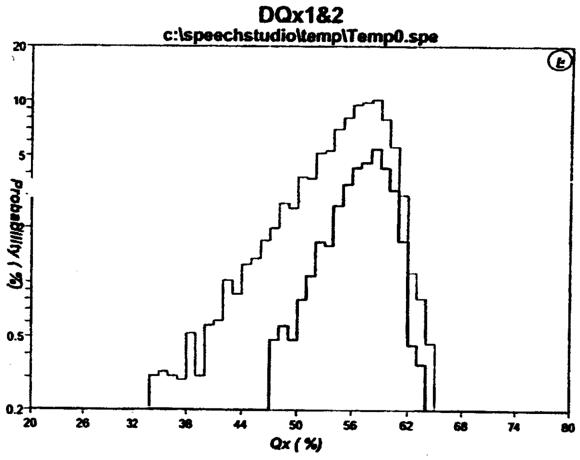
LM03 POST

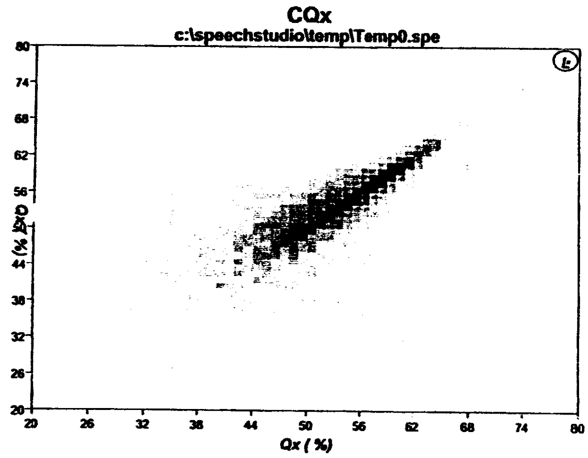












Graph	Samples	< >	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	6517	0, 0	114.87Hz	108.42Hz	113.71Hz	62.15	96.8, 140.3Hz	92.7, 146.4Hz	
VRP1&2	6487	30, 0							
CFx	6236	0, 0							12.14%
QxFx1&2	6501	16, 0							
DQx1&2	6501	16, 0	54.50 %	58.50 %	55.89 %	6.05	46.8, 60.3 %	42.9, 61.4 %	
CQx	6214	5, 0							28.56%

Table 11: Results for LM03 (Male; 32 years; teacher)

	Pre-LMT	Post-LMT
DFx1&2	• First and second order distributions are similar • Some low frequency distribution at 100-105 Hz (very low probability so not significant) • Sfo: 114.87Hz • 90% range: 93.7, 149.5Hz	• First and second order distributions similar shape and size • Sfo: 114.87Hz • 90% range 92.7, 146.4 Hz
CFx	• the diagonal line is broad and there are areas of scatter on either side • irregularity percentage 13.95%	• the diagonal line is broad • smaller areas of scatter on either side • irregularity percentage 12.14%
QxFx1&2	• main concentration of closed phase is at normal mode of 100-160 Hz	• main concentration of closed phase is 100-160 Hz
DQx1&2	• mean speaking closure quotient: 53.50%	• 54.50% of each cycle, vocal folds are closed
CQx	• broad diagonal line 29.27% • scatter	• broad diagonal line 28.56%

Interpretation:

Frequency range, mean speaking fundamental frequency and regularity:

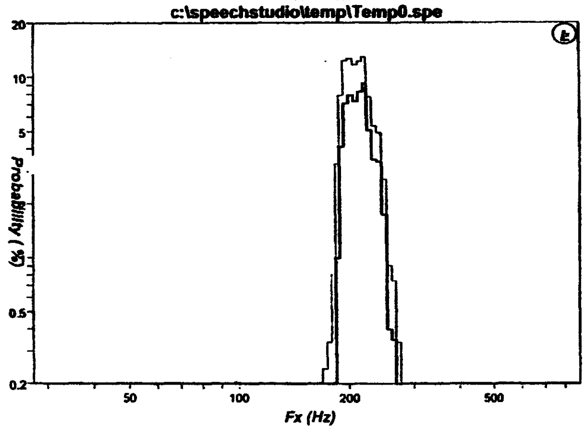
The results show very little change after manual therapy and does not deviate greatly from a normal male speaker. DFx1&2 shows a fairly wide pitch range and an appropriate mean fundamental frequency period range of around 114.87Hz (Carding, 2000), lower than female participants as is expected and as this is associated with a lower pitch. However, the CFx shows that before and after therapy, this speaker's irregularity in phonation is very high suggesting roughness in the voice (Fourcin, 2000), which decreases just over 1% after manual therapy.

Physical correlates for quality and control of voice:

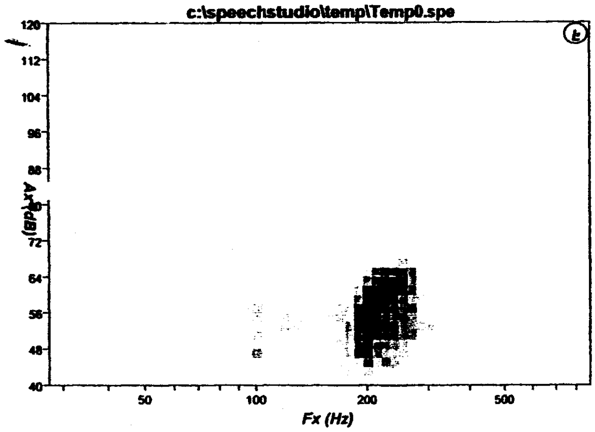
The QxFx shape reflects appropriate vocal fold closure around the appropriate frequency for this speaker and this does not change after therapy. The DQx1&2 figure shows the ratio of closed to open phase for each cycle. Although a longer closed phase is usually associated with hoarseness (Fourcin et al., 2002), we would expect that as a male, this participant would have a relatively higher percentage of closure quotient as males tend to have less breathy voices. However, the results show little change and start within the range for normal voice (Appendix V).

LH05 PRE

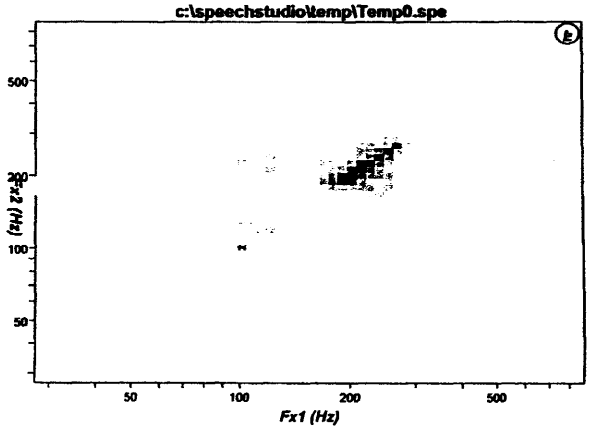
DFx1&2
c:\speechstudio\temp\Temp0.spe



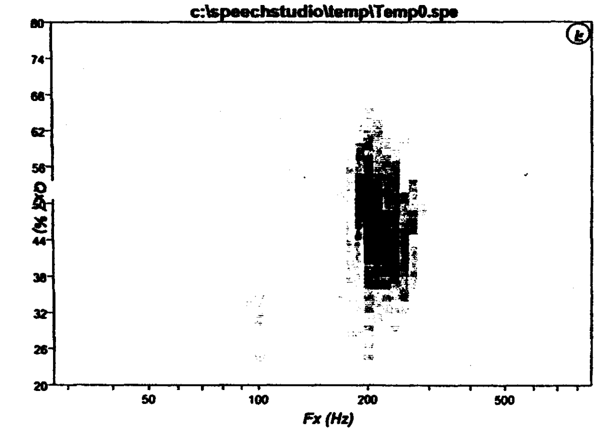
VRP1&2
c:\speechstudio\temp\Temp0.spe



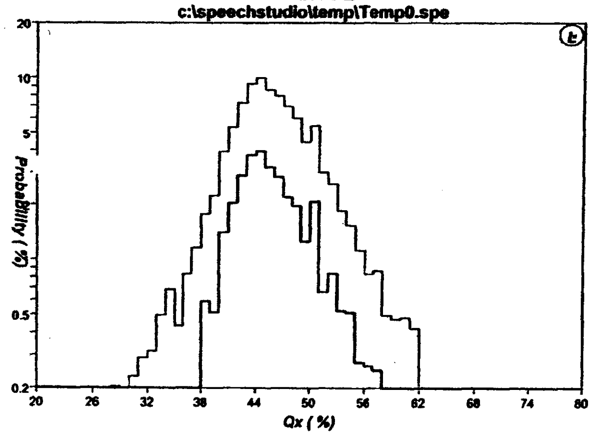
CFx
c:\speechstudio\temp\Temp0.spe



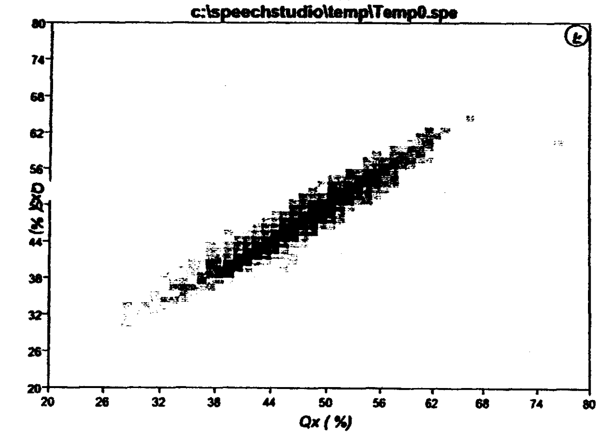
QxFx1&2
c:\speechstudio\temp\Temp0.spe



DQx1&2
c:\speechstudio\temp\Temp0.spe



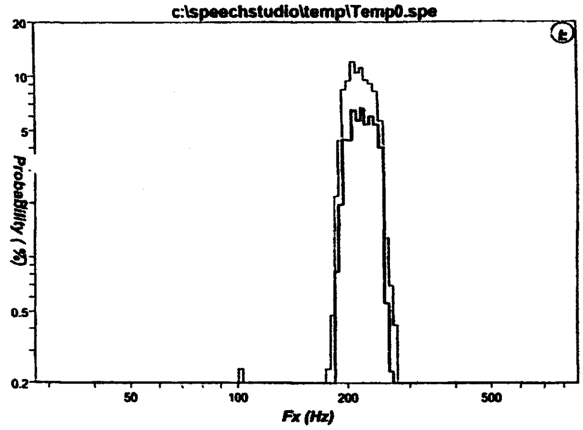
CQx
c:\speechstudio\temp\Temp0.spe



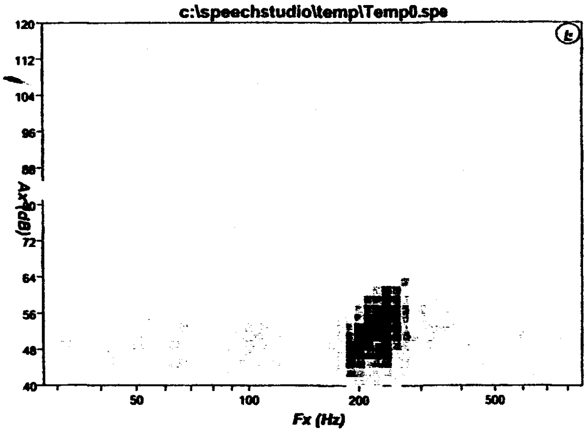
Graph	Samples	<>	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	8261	0, 0	210.67Hz	223.20Hz	212.87Hz	59.95	192.5, 239.9Hz	187.2, 247.1Hz	
VRP1&2	8259	2, 0							
CFx	7997	0, 0							5.54%
QxFx1&2	8231	19, 11							
DQx1&2	8231	19, 11	45.50 %	44.50 %	45.56 %	5.85	40.2, 52.8 %	37.9, 55.9 %	
CQx	7951	1, 14							24.71%

LM05 POST

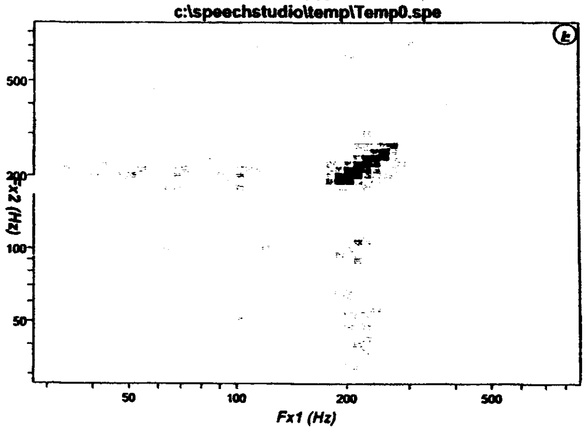
DFx1&2
c:\speechstudio\temp\Temp0.spe



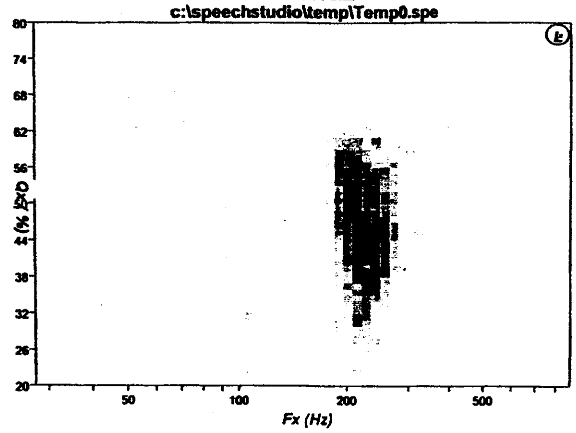
VRP1&2
c:\speechstudio\temp\Temp0.spe



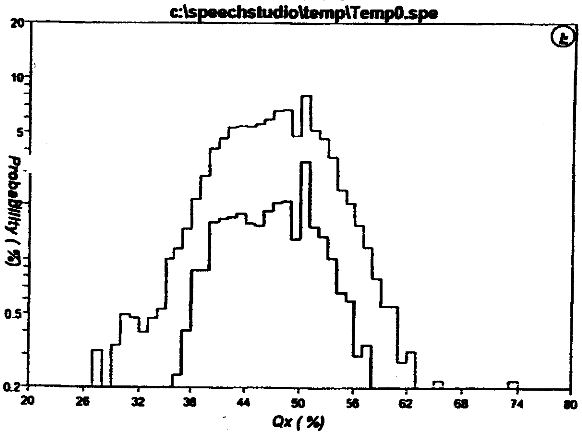
CFx
c:\speechstudio\temp\Temp0.spe



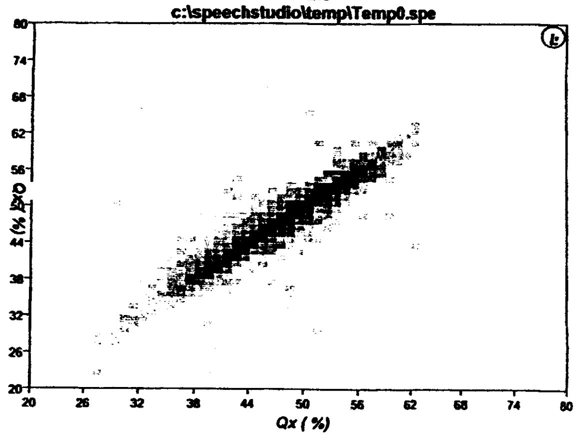
QxFx1&2
c:\speechstudio\temp\Temp0.spe



DQx1&2
c:\speechstudio\temp\Temp0.spe



CQx
c:\speechstudio\temp\Temp0.spe



Graph	Samples	<>	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	5433	0, 0	210.67Hz	210.67Hz	218.67Hz	88.33	193.8, 246.6Hz	184.1, 252.8Hz	
VRP1&2	5387	46, 0							
CFx	5171	0, 0							10.23%
QxFx1&2	5032	384, 17							
DQx1&2	5032	384, 17	46,50 %	50.50 %	47.18 %	6.90	39.2, 54.6 %	36.3, 57.4 %	
CQx	4673	8, 14							31.63%

Table 12: Results for LM05 (female, 21 years; student accountant)

	Pre-LMT	Post-LMT
DFx1&2	• First and second order distributions are similar shape and size • Sfo: 210.67Hz • 90% frequency range: 187.2, 247.1Hz	• First and second order distributions still very similar • Sfo: 210.67Hz • Low frequency distribution around 100-105Hz (low probability so not significant) • 90% range 184.1, 252.8Hz
CFx	• short, broad line • some scatter • irregularity 5.54%	• short, broad line • irregularities shown by lines present on either side of diagonal line • irregularity increased to 10.23%
QxFx1&2	• wide range of closure Some closure at 100Hz, the majority from 200-300Hz	• more contained around 200-300 Hz
DQx1&2	• mean speaking closure quotient: 45.50%	• mean speaking closure quotient: 46.50%
CQx	• 24.71%	• 31.63%

Interpretation:

<u>Frequency range, mean speaking fundamental frequency and regularity:</u>

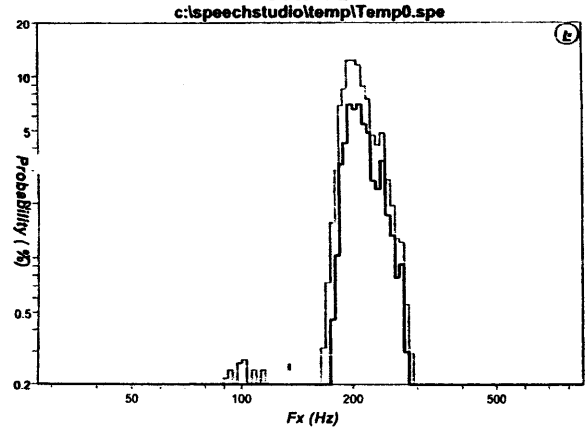
DFx1&2 shows a normal shaped plot around a mean of 210.67 Hz frequency which is within normal limits for female speaking fundamental frequency (Carding, 2000) and does not change after therapy. Her pitch range, which is significantly limited pre-therapy, increases only slightly after manual therapy shown by the 90% range figures. There are some low frequency distributions which are not significant but unusual in that they have appeared after therapy. However, this corresponds with indication from the rest of the results that there has been slight change for worse. The CFx plot shows increased irregularity in the lower end of fundamental frequency range which is reflected in the almost 5% increase in percentage irregularity; this is associated with hoarseness (Fourcin, 2000).

<u>Physical correlates for quality and control of voice:</u>

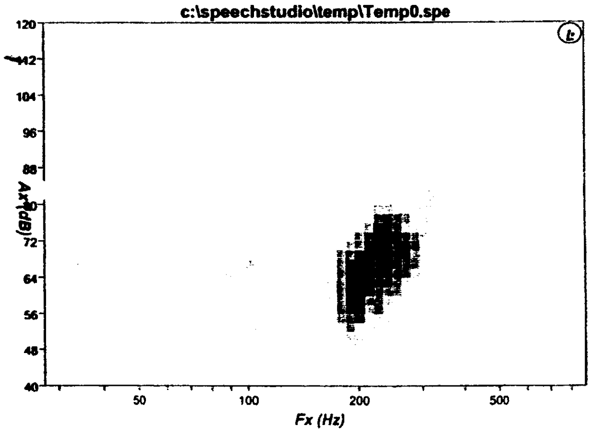
There is little change in the parameters related to quality of voice. However, the CQx plot shows variability of the closed phase from cycle to cycle worsens after therapy shown by the increased scattered organization and the greater percentage of irregularity by almost 7%.

LM06 PRE

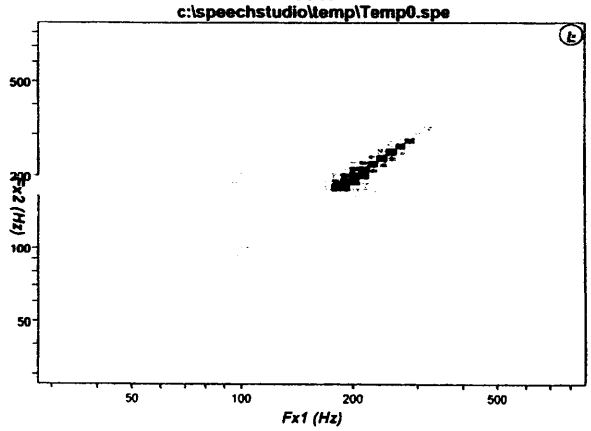
DFx1&2
c:\speechstudio\temp\Temp0.spe



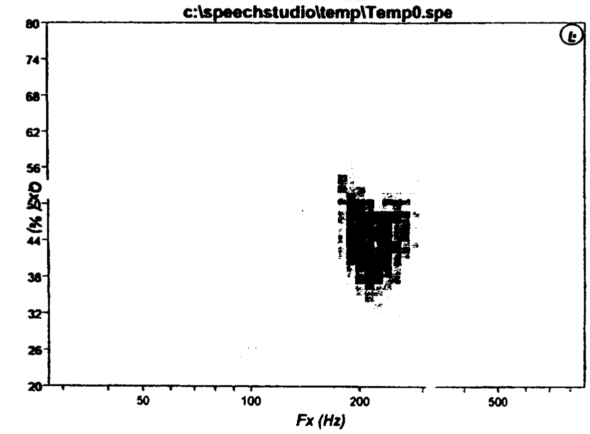
VRP1&2
c:\speechstudio\temp\Temp0.spe



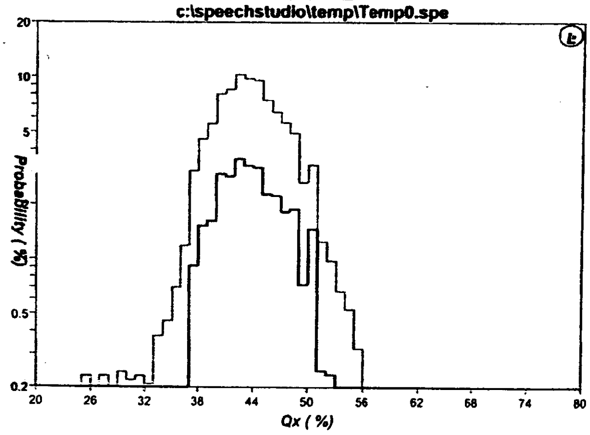
CFx
c:\speechstudio\temp\Temp0.spe



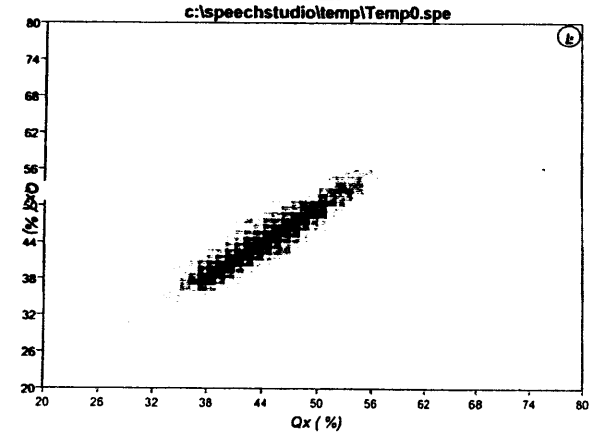
QxFx1&2
c:\speechstudio\temp\Temp0.spe



DQx1&2
c:\speechstudio\temp\Temp0.spe



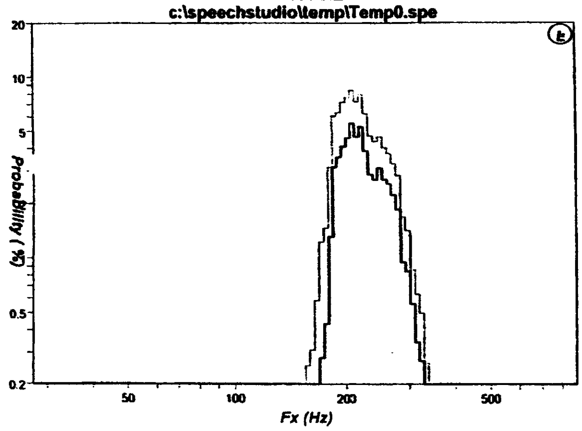
CQx
c:\speechstudio\temp\Temp0.spe



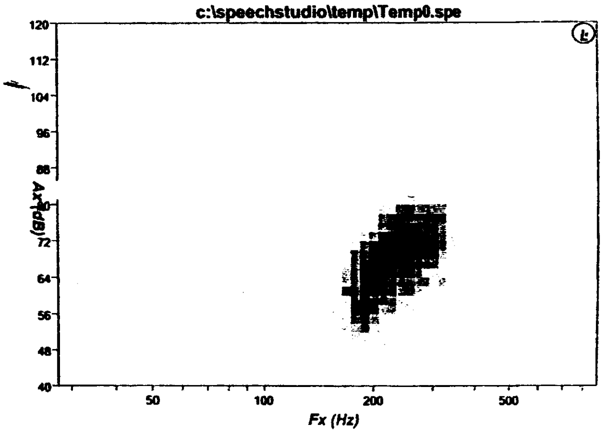
Graph	Samples	< >	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	8811	0, 0	204.68Hz	198.85Hz	207.98Hz	68.00	185.6, 244.9Hz	176.1, 257.5Hz	
VRP1&2	8811	0, 0							
CFx	8273	0, 0							8.09%
QxFx1&2	8670	134, 7							
DQx1&2	8670	134, 7	43.50 %	42.50 %	43.47 %	5.14	38.4, 49.2 %	36.9, 50.9 %	
CQx	8091	4, 9							26.99%

LM06 POST

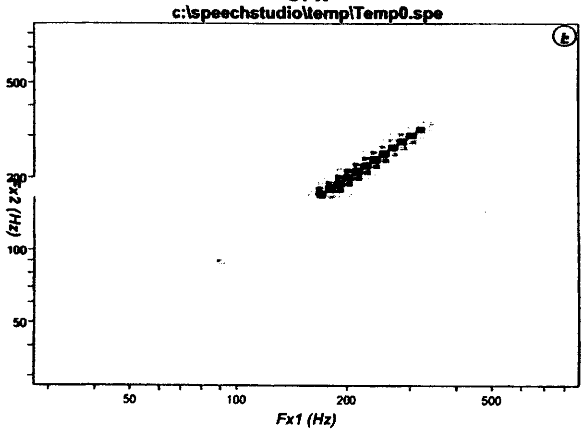
DFx1&2
c:\speechstudio\temp\Temp0.spe



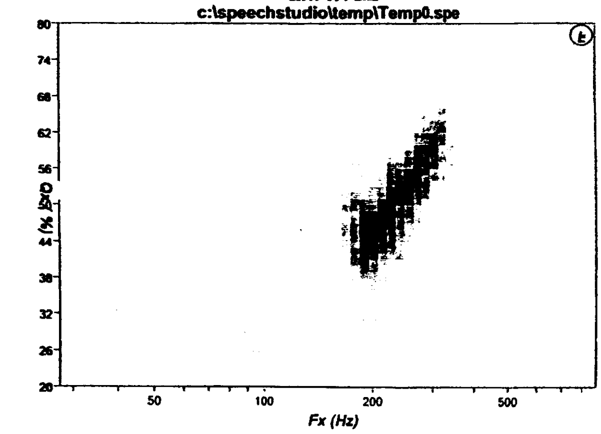
VRP1&2
c:\speechstudio\temp\Temp0.spe



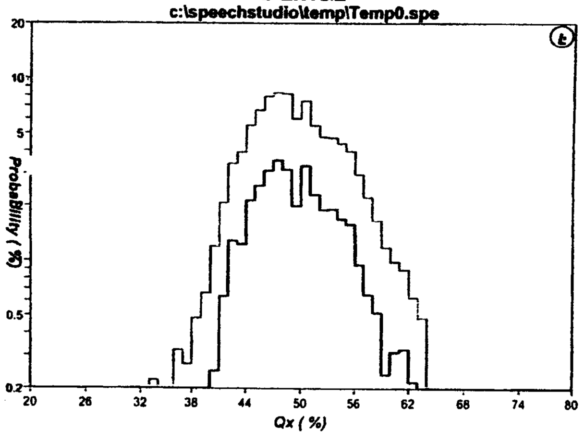
CFx
c:\speechstudio\temp\Temp0.spe



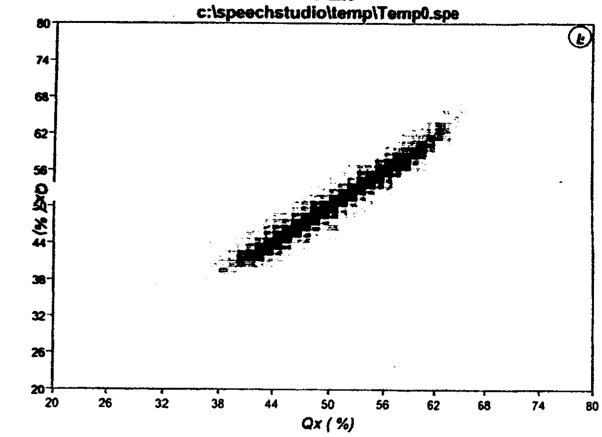
QxFx1&2
c:\speechstudio\temp\Temp0.spe



DQx1&2
c:\speechstudio\temp\Temp0.spe



CQx
c:\speechstudio\temp\Temp0.spe



Graph	Samples	<>	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	10243	0, 0	216.85Hz	210.67Hz	217.92Hz	68.35	185.6, 273.1Hz	175.8, 287.5Hz	
VRP1&2	10242	1, 0							
CFx	9624	0, 0							5.55%
QxFx1&2	9877	363, 3							
DQx1&2	9877	363, 3	48.50 %	47.50 %	48.90 %	5.86	43.0, 56.7 %	41.3, 59.2 %	
CQx	9209	3, 3							20.73%

Table 13: Results for LM06 (female; 19 years; singing student)

	Pre-LMT	Post-LMT
DFx1&2	• First and second order distributions are similar shape and size • very small low frequency distribution at around 100 Hz (very low probability so not significant) • Sfo: 204.68Hz • 90% range: 176.1, 257.5 Hz	• First and second order distributions are similar shape and size • Low frequency distributions not present • Sfo:216.85 Hz • 90% range: 175.8,287.5 Hz
CFx	• compact but broad diagonal line • irregularity 8.09%	• compact diagonal line is slightly longer, less scatter in lower frequencies • irregularity 5.55%
QxFx1&2	• heart shape organization of plots • Sometimes is closed up to 56% of the time	• organization is diagonal shape • plots extend up high on % axis •
DQx1&2	• mean speaking closure quotient:43.5%	• mean speaking closure quotient: 48.5%
CQx	• 26.99% • broad diagonal line	• 20.73% • broad diagonal line

Interpretation:

Frequency range, mean speaking fundamental frequency and regularity:

The similar shape and size of first and second order distributions in DFx plot before and after therapy show regularity which is associated with normal vocal fold vibration, however, her pitch range has improved after therapy.

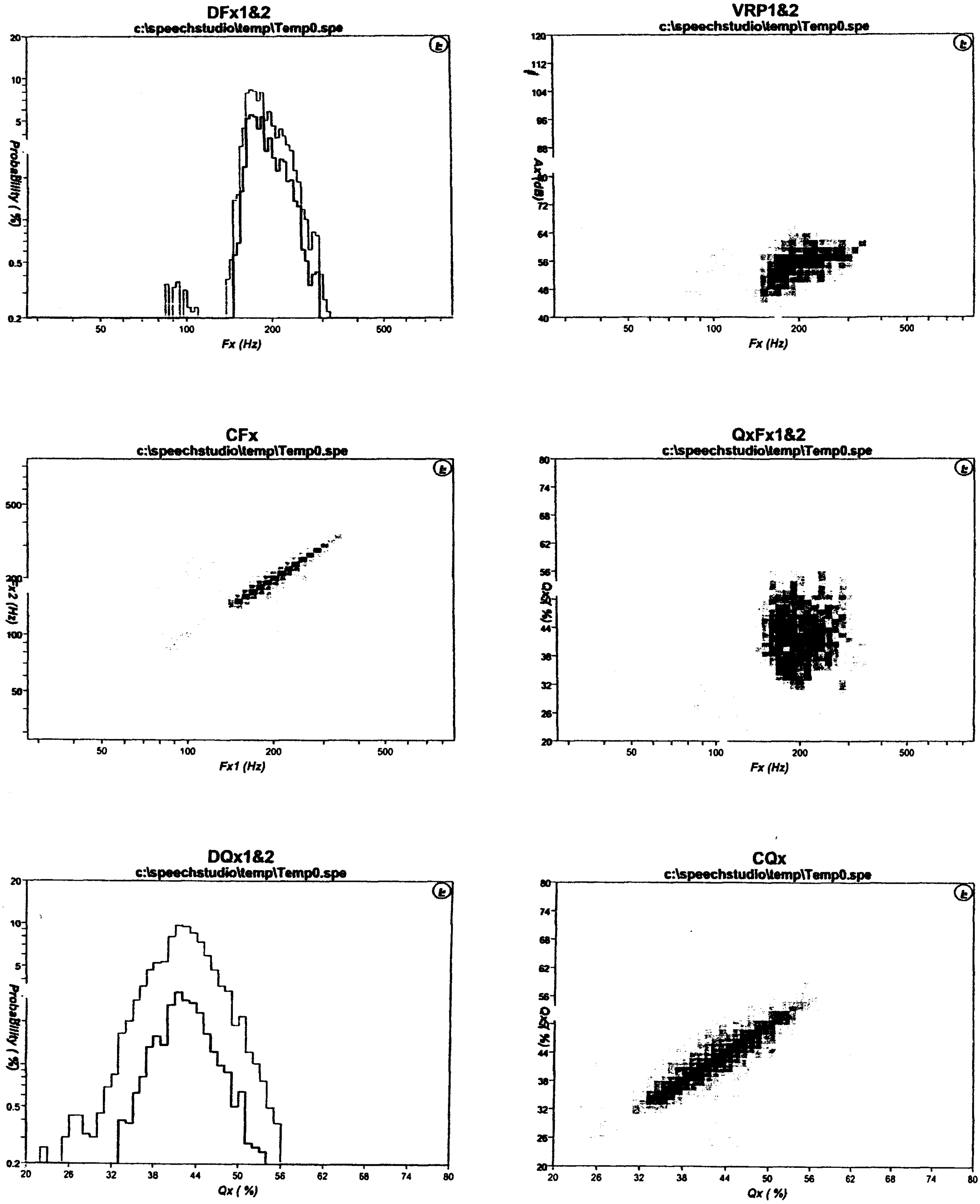
The irregularity shown in the CFx plot toward the end of the participant's main frequency range improves after therapy as scatter decreases as does the corresponding numerical indicator by about 2.5%.

Physical correlates for quality and control of voice:

The distribution on the QxFx plot shows the speaker's vocal folds are closed about 40% of the time at the lower end of her frequency range, whereas at the higher range they are closed a longer percentage of the time (over 60%). The change from a heart shape to diagonal shape after therapy shows that vocal fold closure varies with pitch, her vocal folds are closed more often when phonating at higher frequencies which reflects a lack of control. The percentage of closed to open ratio has increased which is an improvement as it started rather low which can be suggestive of excessive breathiness.

It is unusual for women to have a shorter open phase as their voices tend to be breathier, however, this could be related to the way that she projects her voice as a professional voice user. Overall, the speaker shows improvement, which was supported by her own report that soreness had been reduced.

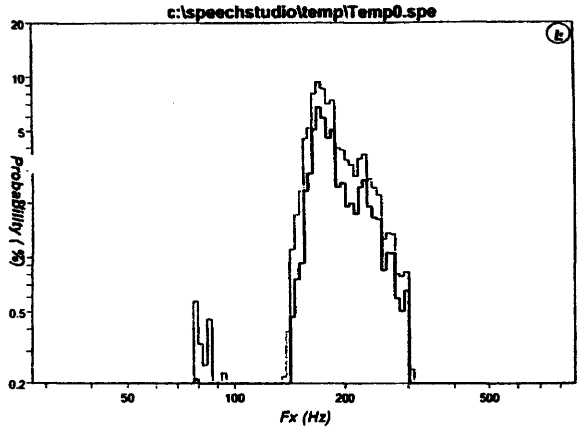
LH07 PRE



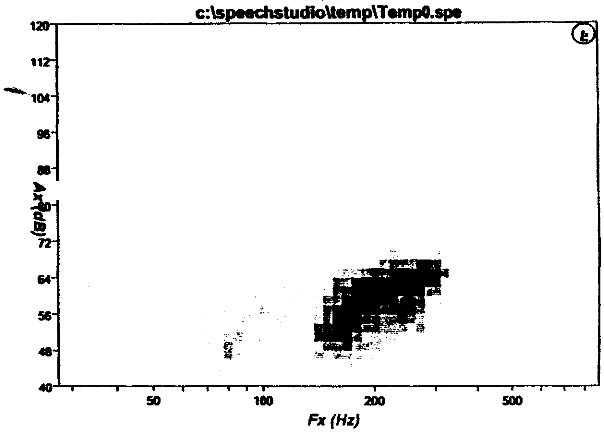
Graph	Samples	< >	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	6328	0, 0	182.34Hz	172.11Hz	186.24Hz	79.83	156.7, 239.6Hz	129.1, 259.0Hz	
VRP1&2	6323	5, 0							
CFx	5842	0, 0							8.87%
QxFx1&2	6235	91, 2							
DQx1&2	6235	91, 2	41.50 %	41.50 %	42.23 %	5.71	35.6, 48.7 %	33.3, 51.0 %	
CQx	5719	10, 3							33.90%

LMU+ ROS I

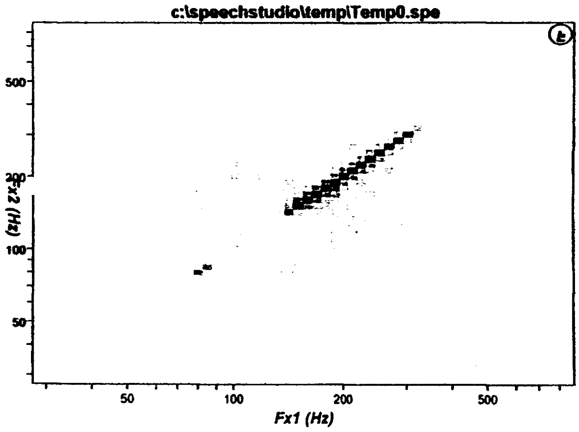
DFx1&2
c:\speechstudio\temp\Temp0.spe



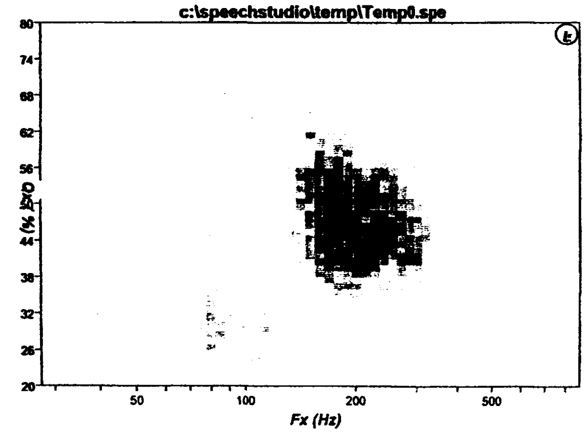
VRP1&2
c:\speechstudio\temp\Temp0.spe



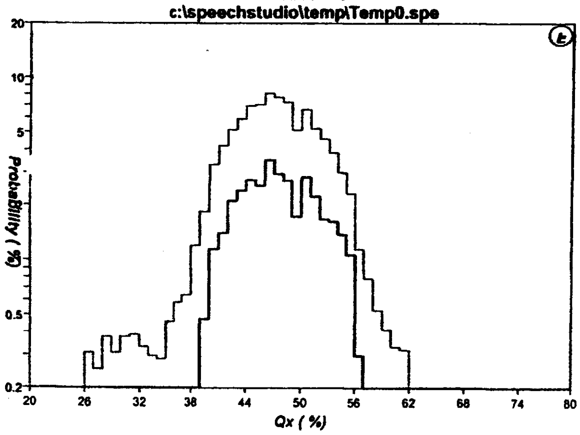
CFx
c:\speechstudio\temp\Temp0.spe



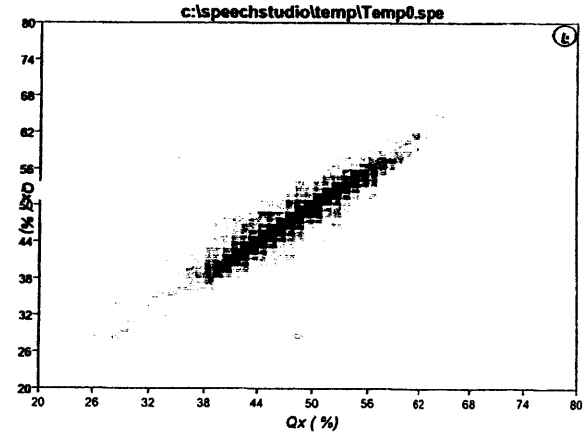
QxFx1&2
c:\speechstudio\temp\Temp0.spe



DQx1&2
c:\speechstudio\temp\Temp0.spe



CQx
c:\speechstudio\temp\Temp0.spe



Graph	Samples	<>	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	8734	0, 0	182.34Hz	172.11Hz	182.17Hz	80.20	153.9, 244.2Hz	131.3, 264.8Hz	
VRP1&2	8720	14, 0							
CFx	8054	0, 0							8.36%
QxFx1&2	8696	26, 12							
DQx1&2	8696	26, 12	46.50 %	46.50 %	47.09 %	6.18	40.5, 54.0 %	37.8, 55.9 %	
CQx	8012	5, 10							23.40%

Table 14: Results for LM07 (female; 25 years; actress & dancer)

	Pre-LMT	Post-LMT
DFx1&2	• First and second order distributions are similar shape and size • small low frequency distribution at around 80-100 Hz • Sfo: 182.34 Hz	• First and second order distributions are similar shape and size • small low frequency distribution at around 80-100 Hz • Sfo:182.34 Hz
CFx	• slightly broad, diagonal line with areas of scatter on either side • irregularity :8.87%	• slightly broad diagonal line; distribution is less scattered than pre therapy • irregularity:8.36%
QxFx1&2	• heart shape distribution with some scatter in lower frequencies • main concentration of closed phase ratio is at around 180 Hz	• heart shape distribution with less scatter in lower frequencies • main concentration of closed phase ratio is at around 180 Hz
DQx1&2	• mean: 41.50%	• mean: 46.5%
CQx	• irregularity of closure:33.90%	• irregularity of closure:23.40%

Interpretation:

Frequency range, mean speaking fundamental frequency and regularity:

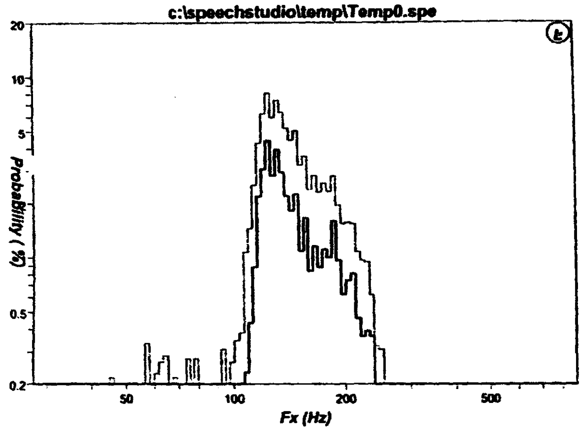
The DFx1&2 plot before and after therapy show a clear cut distribution with a small amount of irregularity which is of quite low probability, therefore, this participant's pre-therapy vocal fold vibration is mostly regular, with the mean fundamental frequency within normal limits for a young woman. Her frequency range is also normal, and widens slightly after therapy. The CFx plot shows some irregularity in lower frequencies which is reduced slightly after therapy.

Physical correlates for quality and control of voice:

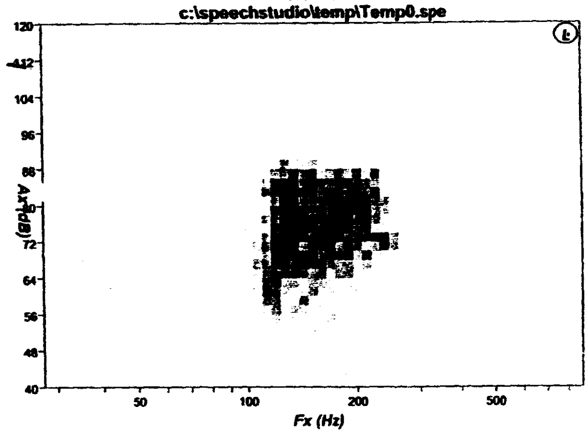
Before therapy, her voice quality is good as shown by the QxFx1&2; the heart of the contact phase ratio distribution is fairly well formed and shows control around the centre register (around 200Hz), although there are some outlying irregularities. This changes slightly after therapy in that there is a slight tendency for a shorter closed phase at higher frequencies which may be perceived as breathiness; a feature commonly perceived by the tester in speakers after manual therapy; this plot also reflects normal voice quality and improvement in that the closed to open ratio has moved toward 50:50. Variability of vocal fold closure from cycle to cycle has improved as it has decreased by around 10%. Overall, there is little change from pre-therapy features which were within normal limits, but, as predicted, the changes are in the direction of improvement.

LMO8 PRE

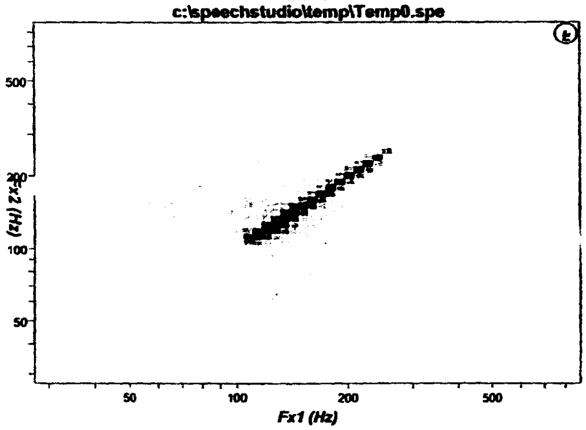
DFx1&2
c:\speechstudio\temp\Temp0.spe



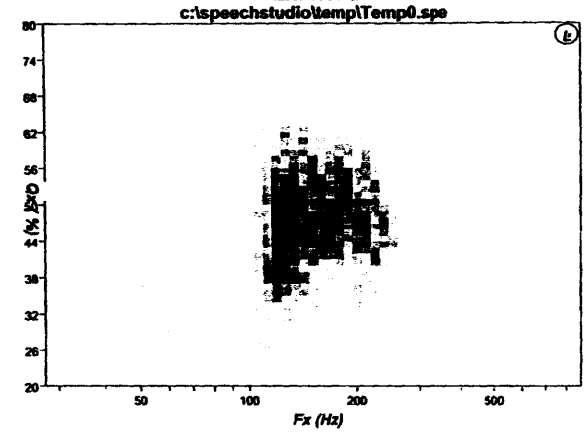
VRP1&2
c:\speechstudio\temp\Temp0.spe



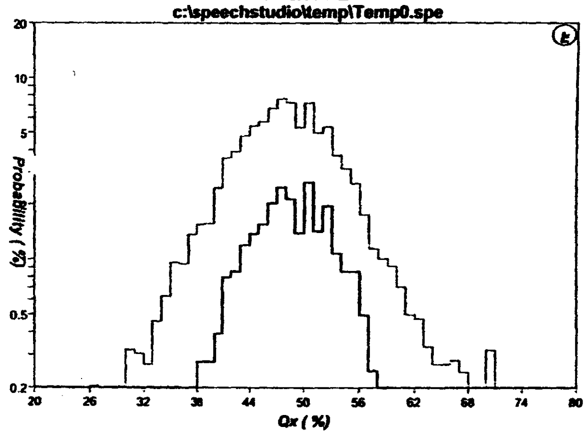
CFx
c:\speechstudio\temp\Temp0.spe



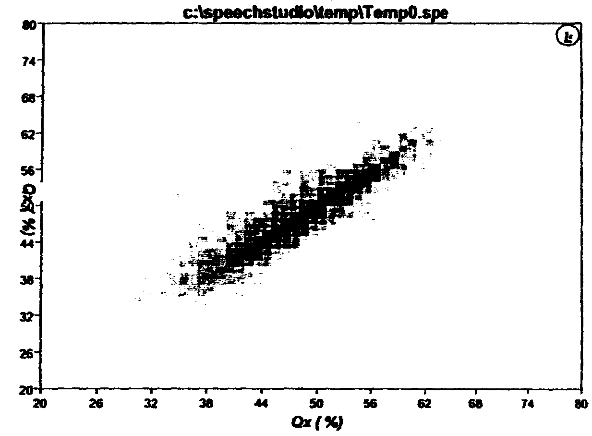
QxFx1&2
c:\speechstudio\temp\Temp0.spe



DQx1&2
c:\speechstudio\temp\Temp0.spe

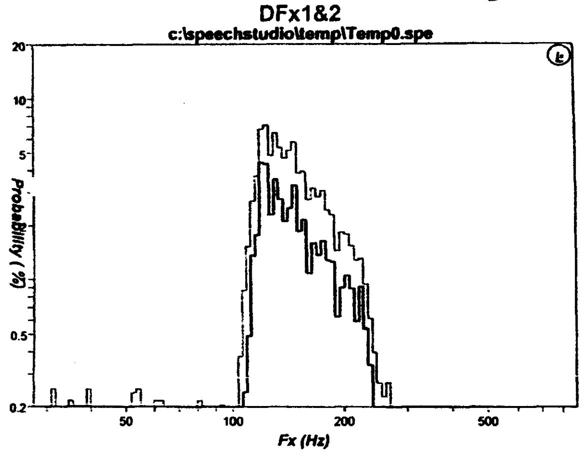


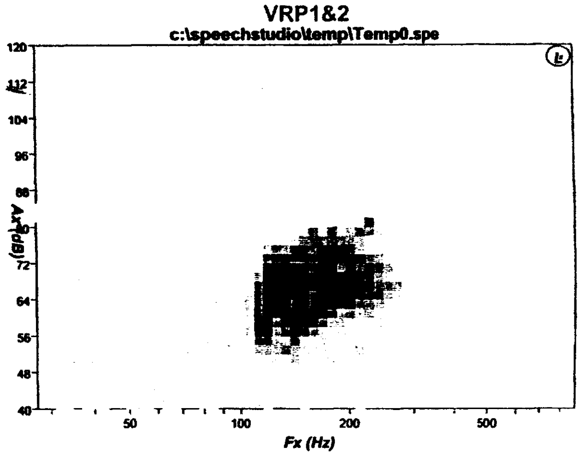
CQx
c:\speechstudio\temp\Temp0.spe

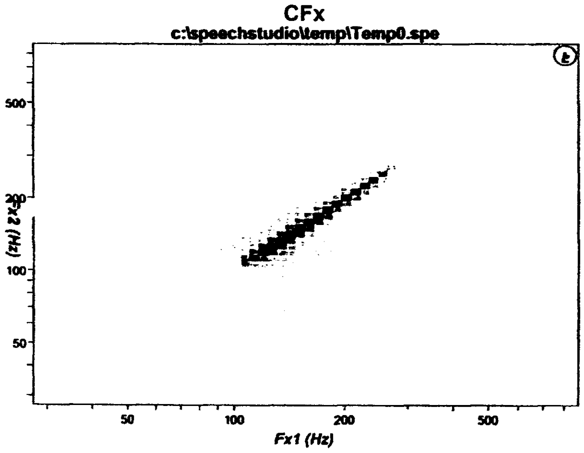


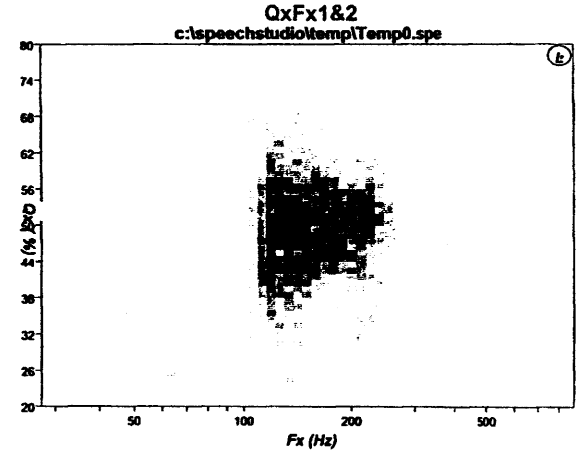
Graph	Samples	< >	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
x1&2	8322	0, 0	136.60Hz	125.27Hz	138.03Hz	97.91	113.4, 196.3Hz	77.2, 216.1Hz	
P1&2	8201	121, 0							
K	7337	0, 0							14.84%
Fx1&2	7786	484, 52							
x1&2	7786	484, 52	47.50 %	47.50 %	47.99 %	7.34	40.2, 56.0 %	37.0, 60.1 %	
K	6809	19, 49							39.01%

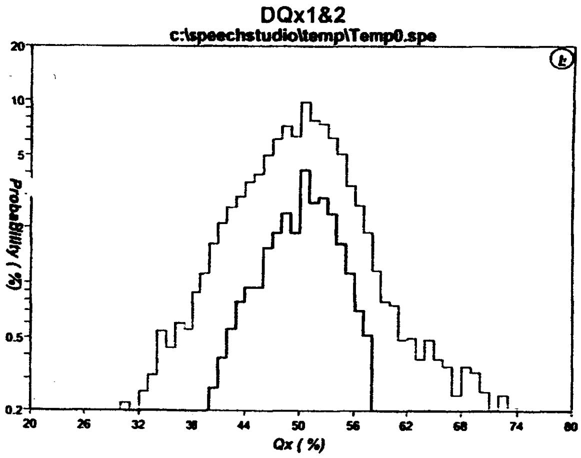
LM08 POST

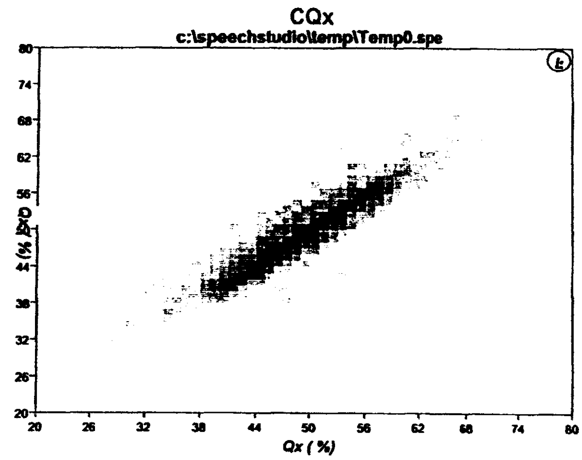












Graph	Samples	<>	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	9248	0, 0	140.61Hz	125.27Hz	141.56Hz	102.83	114.0, 201.4Hz	79.0, 221.3Hz	
VRP1&2	9045	203, 0							
CFx	7921	0, 0							10.77%
QxFx1&2	8620	551, 77							
DQx1&2	8620	551, 77	49.50 %	50.50 %	50.24 %	7.22	42.0, 57.0 %	39.0, 61.7 %	
CQx	7453	21, 67							34.17%

Table 15: Results for LM08 (male; 28 years; student & amateur singer)

	Pre-LMT	Post-LMT
DFx1&2	• First and second order distributions are similar shape and size • Some small low frequency distribution at around 50-100 Hz • Sfo: 136.60 Hz • Wide span across frequency range • 90% range:77.2,216.1Hz	• First and second order distributions are similar shape and size • Some small low frequency distribution at around 0-100 Hz • Sfo:140.61 Hz • Wide span across frequency range • 90% range: 79.0,221.3Hz
CFx	• diagonal line 100-300Hz, broader in lower frequencies shows some irregularity • irregularity: 14.84%	• diagonal line, broader in lower frequencies less scattered distribution than pre-LMT • irregularity: 10.77%
QxFx1&2	• heart shape, concentration of plots around mean fundamental frequency	• heart shape, concentration of plots around mean fundamental frequency
DQx1&2	• Closed to open ratio: 47.50%	• Closed to open ratio:49.50%
CQx	• Irregularity of closure:39.01%	• Irregularity of closure:34.01%

Interpretation:

Frequency range, mean speaking fundamental frequency and regularity:

The participant has a high speaking fundamental frequency for a man, we would expect it to be around 112 Hz (Carding, 2000) rather than 136.60Hz, and this increases further after therapy to 140.61 which is not a rare side effect, as we have seen in LM01. However, there is marked improvement in regularity of vocal fold vibration after therapy, shown in the DFx plot as the first and second order distributions have become closer and more similar in shape after. This is again reflected in the decrease in scatter in CFx plots and in the corresponding numerical value.

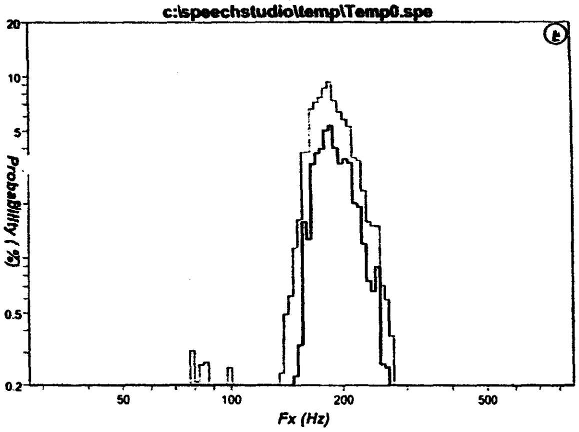
Physical correlates for quality and control of voice:

The speaker's closed phase quotient shows an appropriate balance between open and closed phase, and there is slight improvement shown by a small decrease in irregularity of vocal fold closure.

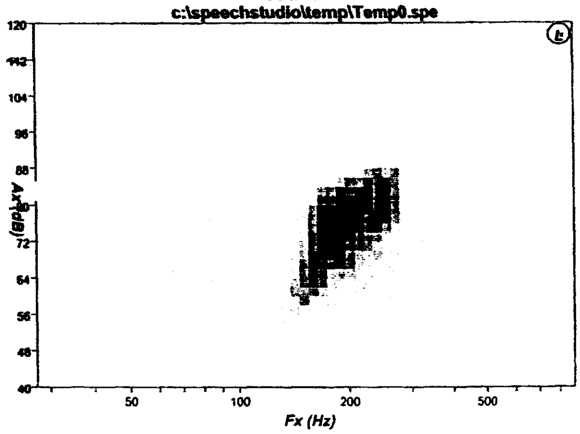
Overall, this speaker shows improvements in voice quality and pitch range after therapy, however, like most other participants, he did not deviate greatly from the norm before therapy.

LM09 PRE

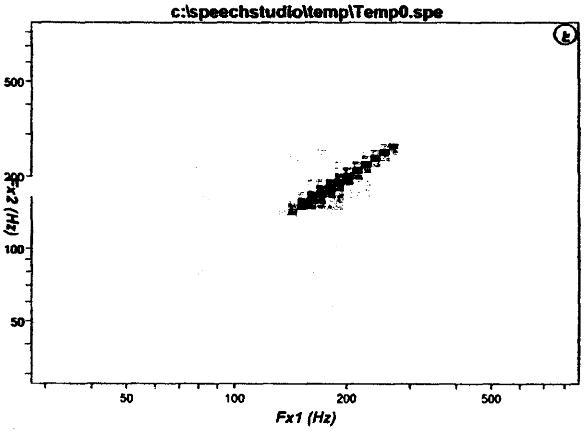
DFx1&2
c:\speechstudio\temp\Temp0.spe



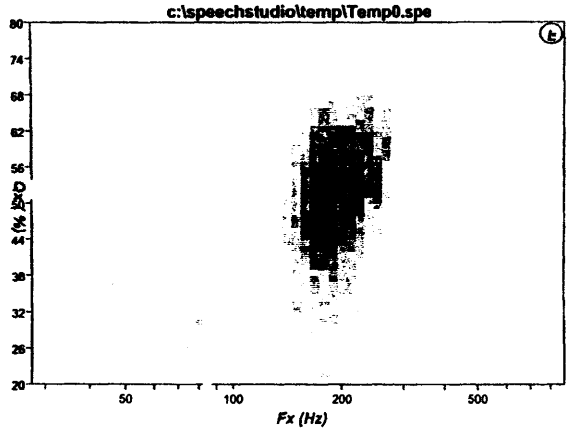
VRP1&2
c:\speechstudio\temp\Temp0.spe



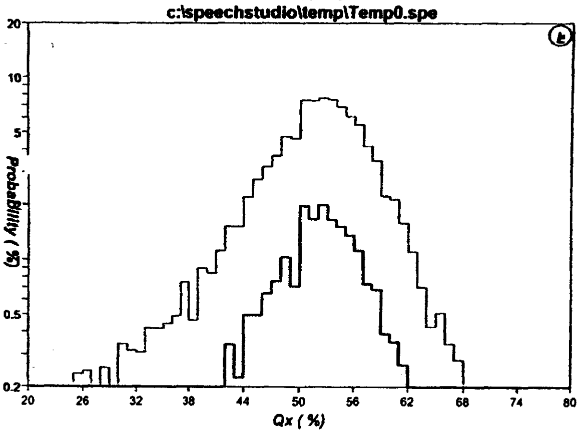
CFx
c:\speechstudio\temp\Temp0.spe



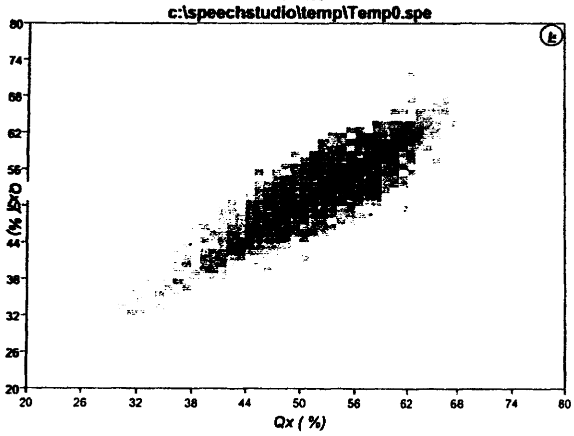
QxFx1&2
c:\speechstudio\temp\Temp0.spe



DQx1&2
c:\speechstudio\temp\Temp0.spe



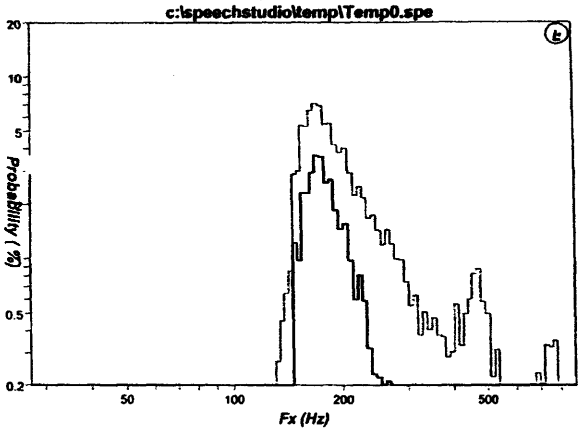
CQx
c:\speechstudio\temp\Temp0.spe



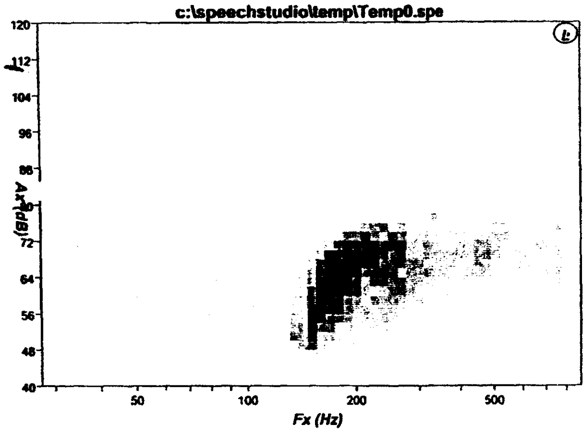
Graph	Samples	< >	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	11984	0, 0	182.34Hz	187.69Hz	186.25Hz	92.85	155.7, 229.1Hz	106.4, 249.2Hz	
VRP1&2	11984	0, 0							
CFx	11140	0, 0							13.86%
QxFx1&2	10992	931, 61							
DQx1&2	10992	931, 61	51.50 %	52.50 %	52.28 %	7.44	43.0, 59.3 %	37.8, 61.7 %	
CQx	10145	87, 56							50.85%

LM09 POST

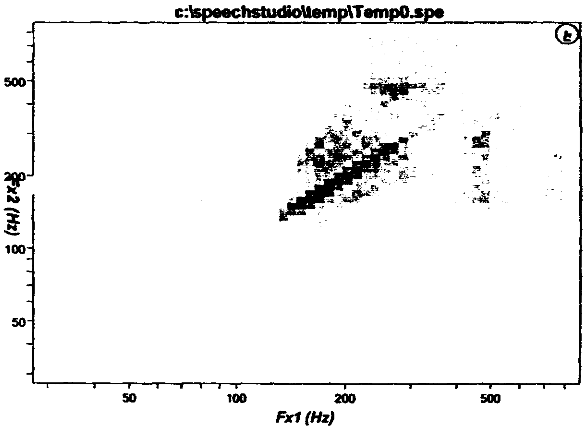
DFx1&2
c:\speechstudio\temp\Temp0.spe



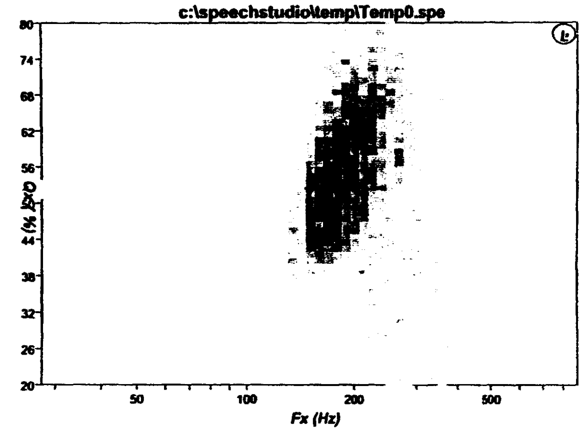
VRP1&2
c:\speechstudio\temp\Temp0.spe



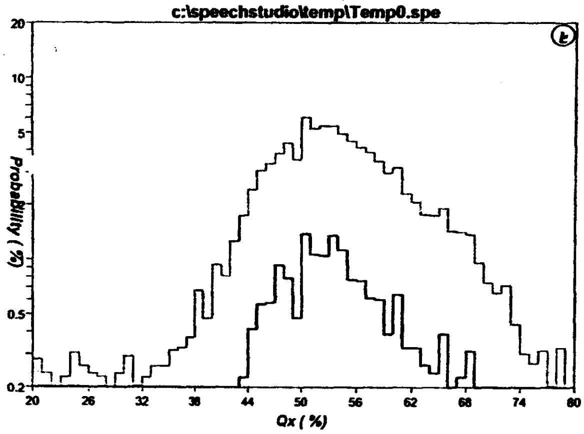
CFx
c:\speechstudio\temp\Temp0.spe



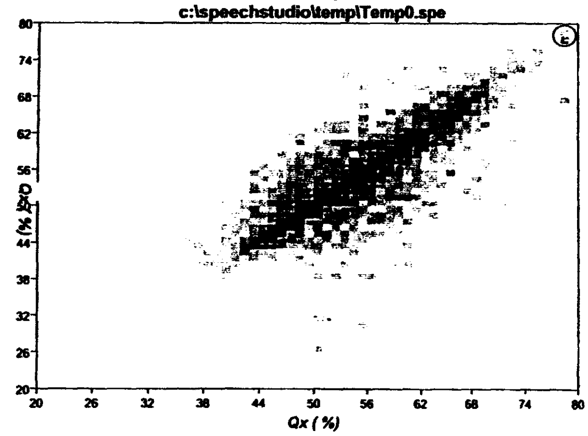
QxFx1&2
c:\speechstudio\temp\Temp0.spe



DQx1&2
c:\speechstudio\temp\Temp0.spe



CQx
c:\speechstudio\temp\Temp0.spe



Graph	Samples	< >	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	10782	0, 0	198.85Hz	172.11Hz	186.20Hz	121.11	152.8, 342.4Hz	142.4, 467.3Hz	
VRP1&2	10779	3, 0							
CFx	9986	0, 0							33.40%
QxFx1&2	8824	1872, 86							
DQx1&2	8824	1872, 86	53.50 %	50.50 %	53.36 %	9.46	43.7, 65.7 %	38.6, 69.2 %	
CQx	7567	469, 110							55.09%

Table 16: Results for LM09 (female; 55 years; housewife)

	Pre-LMT	Post-LMT
DFx1&2	• First and second order distributions are similar in shape and size • Some small low frequency distribution at around 85-100 Hz (not significant) • SFo: 182.34 Hz • Narrow span across frequency range • 90% range:106.4,249.2Hz	• Second order distributions different in shape and size, wider than first order distribution • Additional peak at an abnormal mode around 500 Hz • SFo: 198.85 Hz • 90% range: 142.5,467.3Hz
CFx	• small, broad diagonal line • irregularity:13.86%	• very broad diagonal line with areas of scatter either side in higher frequencies • irregularity:33.41%
QxFx1&2	• main concentration of closed phase around fundamental frequency • well contained shape	• extensive scatter • distribution extends up to 80%
DQx1&2	• 51.50%	• 53.50%
CQx	• broad diagonal line • irregularity of closure: 50.85%	• broad diagonal line with extensive scatter • irregularity of closure: 55.10%

Interpretation:

Frequency range, mean speaking fundamental frequency and regularity:

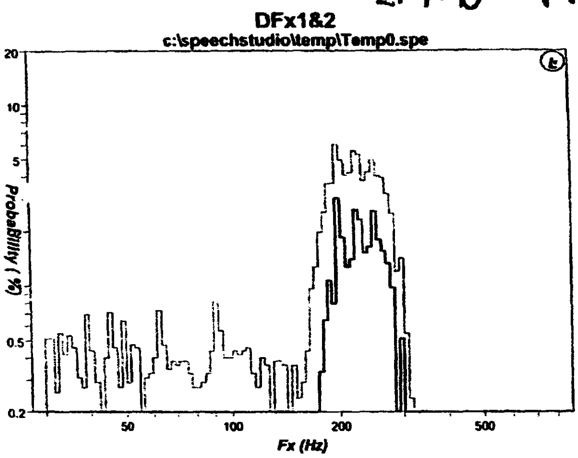
This speaker's results are significantly worse after therapy. The pre-therapy DFx plot displays a normal symmetrical shape and size distribution, with an appropriate fundamental frequency of 182.34 Hz, and although her frequency range is narrow, first and second order distributions are close in shape and size reflecting regularity of phonation. After therapy, the first and second order distributions are very different, reflecting irregularity of vocal fold vibration. In addition, the second order distribution is ill-formed and wide and shows another peak even though it is low probability (about 1 to 1.5%). This could reflect characteristics of a diplophonic voice (there is no published data at present for this feature) which is supported by the scatter on either side of the broad diagonal line in the higher frequencies on the CFx plot.

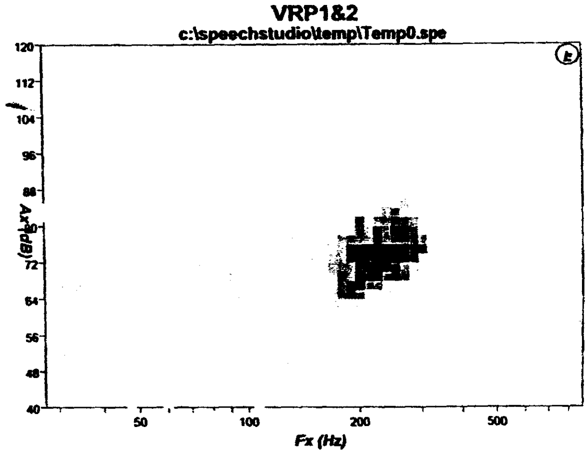
Physical correlates for quality and control of voice:

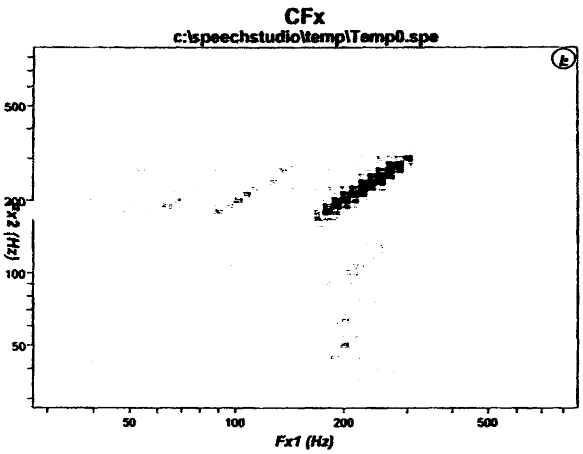
Post therapy, the QxFx displays a lot of scatter, the distribution reaches up to 80% along the percentage of contact quotient axis (x-axis); this shows some very long closed phase moments within cycles. Variability of the ratio of closed to open phase from cycle to cycle (CQ) increases by 5% after therapy.

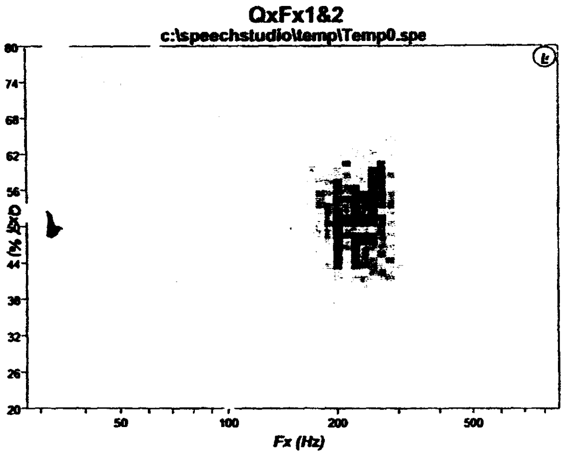
The worsened vocal features could be attributed to a number of factors which will be further explored in the discussion. As this is quite severe, it is a possibility that there was increased mucous after treatment as this is a possible side-effect noted by Lieberman (in Harris et al., 2000). However, the patient reported feeling less sore and "better" after therapy.

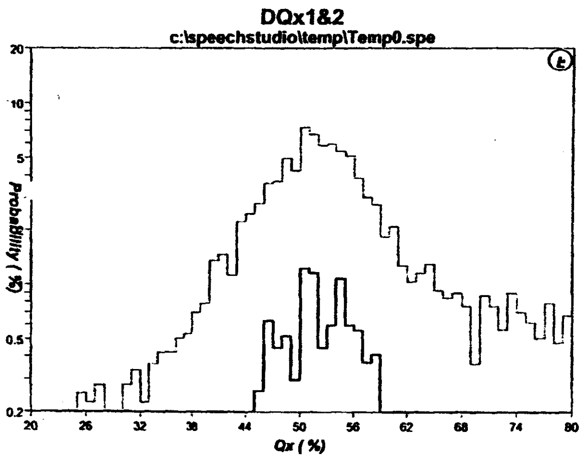
LM10 PRE

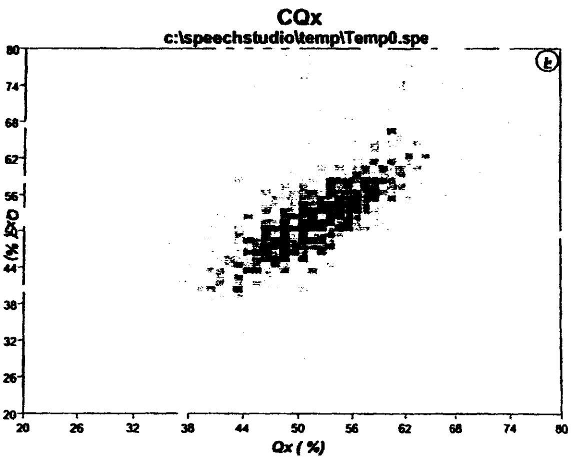








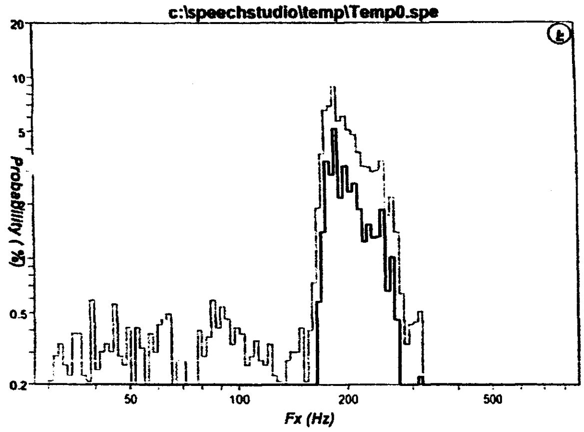




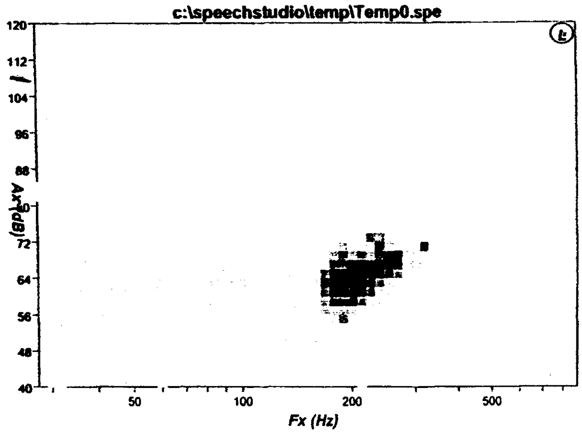
Graph	Samples	< >	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	5453	0, 0	167.21Hz	198.85Hz	209.43Hz	197.20	59.8, 271.8Hz	41.3, 287.4Hz	
VRP1&2	5403	50, 0							
CFx	4467	0, 0							37.72%
QxFx1&2	3544	1837, 72							
DQx1&2	3544	1837, 72	52.50 %	50.50 %	52.26 %	9.61	42.8, 65.7 %	38.2, 72.4 %	
CQx	2624	13, 62							69.44%

LM10 POST

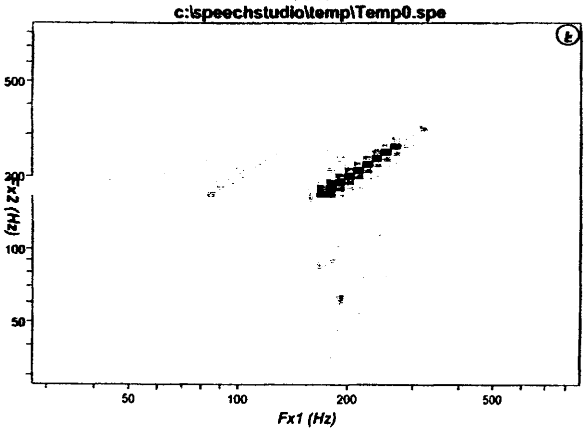
DFx1&2
c:\speechstudio\temp\Temp0.spe



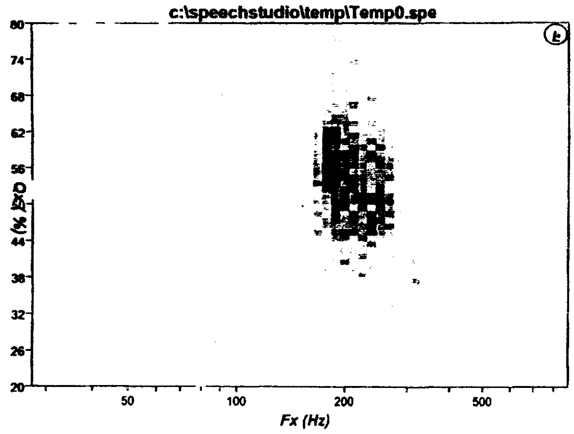
VRP1&2
c:\speechstudio\temp\Temp0.spe



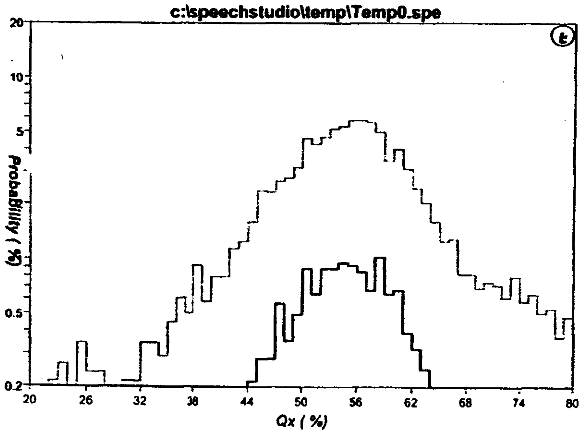
CFx
c:\speechstudio\temp\Temp0.spe



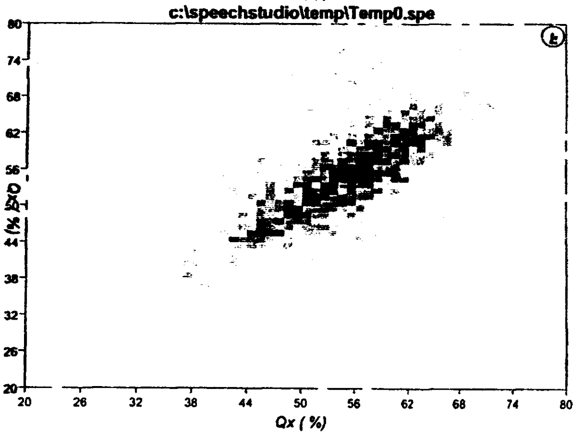
QxFx1&2
c:\speechstudio\temp\Temp0.spe



DQx1&2
c:\speechstudio\temp\Temp0.spe



CQx
c:\speechstudio\temp\Temp0.spe



Graph	Samples	<>	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	6227	0, 0	172.11Hz	187.69Hz	192.64Hz	166.24	73.9, 257.3Hz	46.9, 282.4Hz	
VRP1&2	6135	92, 0							
CFx	4980	0, 0							30.20%
QxFx1&2	3746	2399, 82							
DQx1&2	3746	2399, 82	54.50 %	56.50 %	55.01 %	9.63	43.5, 65.7 %	37.9, 71.4 %	
CQx	2755	17, 71							65.52%

Table 17: Results for LM10 (female; 20 years; actress, singer & dancer)

	Pre-LMT	Post-LMT
DFx1&2	• Unusual distribution in lower frequencies • First and second order distributions are similar in shape and size • Mfo: 167.21Hz • Narrow span across frequency range • 90% range:41.3,287.4Hz	• Unusual distribution in lower frequencies • First and second order distributions are similar in shape and size • Mfo: 172.11Hz • Narrow span across frequency range • 90% range:46.9,282.4Hz
CFx	• irregularity: 37.72%	• irregularity:30.20%
QxFx1&2		
DQx1&2	• 52.50%	• 54.50%
CQx	• irregularity of closure: 69.44%	• irregularity of closure: 65.52%

Interpretation:

Frequency range, mean speaking fundamental frequency and regularity:

Visually analysing the DFx plots, the unusual low probability distributions in lower frequencies may be attributed to external noise when recording. However, there is a clearly defined distribution between the first and second order distributions and an analysis of these results will be carried out on the clear areas. The first and second order distribution before therapy are close in shape and size and move closer after therapy suggesting greater regularity in vocal fold vibration has been achieved despite still being very high at 30.20%. The scatter on either side of the compact diagonal line on the CFx plot reflects the unusual distributions discussed earlier, but the diagonal line itself before and after therapy reflects the regularity visible in the DFx plots.

Physical correlates for quality and control of voice:

The QxFx plot shows that after therapy, the concentration of the distribution is still high showing that the closed phase has not been reduced which is associated with excessive hoarseness. The irregularity of vocal fold closure from cycle to cycle is reduced post-therapy, however it still remains very high and both pre and post CQx plots display a great deal of scatter and a very broad diagonal shape rather than the compact line of a normal voice.

The data for this speaker shows some features which may not have been produced solely by the patient's voice and may be due to technical problems with the equipment. However, these features are very similar in both recordings and therefore may be due to the speaker' pathology, in addition, there is evidence of improvement after therapy.

Discussion

<u>Hypothesis: Physical measures will change for patients with MTD after one session of manual therapy and there will be similarity in the changes across participants.</u>

The physical measures before and after LMT showed change and there were trends in these changes across participants. Most participants showed improvements in the parameters related to fundamental frequency (Sfo, range and regularity) and some change in parameters related to quality of voice after one session of manual therapy:

Although statistical analysis showed that change before and after therapy across these parameters was not significant (apart from pitch which is different for men and women) it is likely that this is due to the small sample size and that with more participants, changes for certain parameters, particularly frequency range, would have been significant. In addition, comparison of individual pre and post therapy within and between subjects of quantitative results and visual information from laryngograph output, suggests that for the majority there was change in aspects related to pitch and quality of voice.

Changes and trends

LMT resulted in change for patients with MTD. The amount of change must be evaluated within the context of the pre-treatment data which showed results that did not deviate greatly from results for normal voices, due to the non-organic nature of MTD. For this reason, dramatic change was not expected unless the patient's pre-treatment data showed dramatic deviation from criteria for a normal voice. In addition, change from parameter to parameter varied. Although means summary for SFo and irregularity of fundamental frequency percentage for the group shows an increase, this figure does not provide information about whether there was improvement across the group; for some participant's, an increase in SFo would show improvement whereas for others this would have been shown by a decrease, depending on their pre-therapy figure. In addition, SFo values will also depend on corresponding norms according to gender. Therefore these have been evaluated when looking at each on an individual basis.

For the majority, speaking fundamental frequency moved closer to their appropriate norm, pitch range increased and irregularity of vocal fold vibration was reduced, which is consistent with findings from previous studies (Roy & Leeper, 1993; Roy, 1994; Roy et al., 1996; Van de Lierde et al., 2004). These outcomes are also consistent with accounts of effects of LMT in the literature (Lieberman in Harris et al., 2001; Mathieson, 2000). Findings for the parameters reflecting quality of voice also showed change, however, the changes were smaller, and did not show always indicate improvement.

There are a number of other factors which may have influenced outcomes, some specific to individuals and some related to the testing process. Factors other than treatment may have produced unusual results, for example, those for the two subjects whose results showed dramatic change away from expected outcomes. It should also be taken into account that 'normal' voices also show variability (Colton & Casper, 1996).

MTD is caused by various factors which can co-exist are variables which should be considered when analyzing the data. The varying symptoms across subjects, and co-existing conditions in some cases, may have resulted in outcomes being different for different subjects. For this reason detailed information about the participants should be available. For example, one of the patients whose results worsened after therapy had a history of catarrh and an increase of mucous due to manual therapy. Another participant had a history of gastroesophageal reflux which can cause inflammation and thickening of vocal folds. All these factors affect vocal fold vibration and as a consequence impact upon laryngograph results. Other relevant factors include information about medication which can affect levels of secretions. Medication such as the contraceptive pill and hormone replacement treatment (as well as the menstrual cycle) affects secretions, which in turn affects the elasticity and the vibration of vocal folds. This information was not available.

It is not possible to account for the emotional and psychological situation of each participant at the time of testing and these factors impact greatly on voice (Mathieson, 2001). In addition, the preceding voice clinic appointment may have affected different participants in different ways with relation to anxiety, stress and physical tolerance to rigid stroboscopy. The testing procedure will affect patients differently, as will the rapport with the tester and with clinicians. Laryngeal manual therapy addresses the symptoms of discomfort and provides the patient with 'hands-on' attention from the therapist, which in itself can produce a beneficial response in alleviating anxiety as well as symptoms of tension.

There are also limitations imposed by instrumental testing which only gives indirect evidence of vocal function (Behrman et al., 1997). The patient's voice may not be the same as in his actual environment due to the intermittent and unpredictable nature of symptoms of muscle tension dysphonia. In addition, a patient may use different vocal behaviour in his own environment than in a test situation. For example a teacher may abnormally lower their pitch to speak more authoritatively in class. These factors also explain why pre-treatment results may not represent the habitual style which led to vocal abuse (Behrman & Orlikoff, 1997). In addition, although instrumental measures are objective, the subjective element of how the data is collected and interpreted must be taken into account as "they are independent of neither the clinician nor the patient" (Behrman & Orlikoff 1997:15).

Overall, a number of outcomes correlate with improvements of LMT as stated in the literature and many subjects reported a decrease in hoarseness, pain and discomfort after therapy which is stated as a benefit of LMT by Lieberman (in Harris 2001).

This study also showed that using instrumentation as a component of assessment and management of voice disorders is beneficial, as it allows mechanical abnormalities to be revealed and clarifies hypotheses made using perceptual-auditory means about the behaviour causing the dysphonia (Behrman & Orlikoff, 1997). This is particularly relevant in disorders such as MTD which do not show physical abnormalities on laryngoscopic examination and individual vocal behaviour varies although speakers may present with the same auditory and perceptual symptoms.

Limitations of design

This study is limited by some factors. The statistical analyses were underpowered due to small numbers. Greater numbers may have showed statistical significance in supporting the observations made from the data. In addition, the tests for gender effects were less reliable as there were only two male participants in the sample.

The use of the laryngograph data required a great deal of subjective interpretation of the cross-plots in order to evaluate the data. However, the findings did not conflict with any of the quantitative data. Another limitation to this study is that although most participants were British English speakers, data for speaking fundamental frequency for American speakers was used as there is no normative data for British speakers as yet.

Future studies

This pilot study is a preliminary stage and explores outcomes of LMT using constrained criteria. Further studies could extend on these findings in a number of ways. For example, it would be of clinical use to see how the improvements some participants experienced immediately after therapy are sustained in the long term. Future studies could also extend on these findings by measuring change for these parameters for speakers with normal voice to see the how manual therapy affects normal speakers compared to patients with MTD. In addition, including measures using other means such as perceptual judgements on outcomes in the short and long term would provide further information on the efficacy

Conclusions

Acoustic parameters measured by the laryngograph were changed for the majority patients with MTD by one session of laryngeal manual therapy, in particular, fundamental frequency range widened and irregularity of vocal fold vibration decreased. These improvements were supported by comments from the participants regarding perceptual improvements after therapy. However, a similar study using a large sample size is needed using a variety of outcome measures to confirm the efficacy of this treatment for patients with MTD. The larnygograph was a useful way of measuring change after this treatment and the data used for this study could be used as a baseline for therapy as well as giving patients visual feedback on aspects of their voice and progress during therapy.

9,227 words

References

Aronson,A,E. (1990). Clinical voice disorders, 3rd Edition. New York: Thieme Stratton

Baken,R.J. (1987). Clinical measurement of speech and voice. London: Taylor and Francis

Behrman,A., & Orlikoff,R. (1997). Instrumentation in voice assessment and treatment: What's the use? American Journal of Speech-Language Pathology, 6,(4), 9-16.

Berry, Epstein, Freeman, MacCurtain & Noscoe (1982). An objective analysis of voice disorders (Part 1 and 2). British Journal of Disorders of communication 17,67.

Boone, D., McFarlane, S., & Von Berg, S. (2005). The Voice and Voice Therapy. Seventh Edition USA: Pearson Education, Inc.

Byng, S., Van der Gaag, A., Parr, S. (1998). International Initiatives in Outcomes Measurement: A perspective from the United Kingdom in C.M. Frattali (Ed.) Measuring Outcomes in Speech Pathology. New York: Thieme Medical Publishers.

Carding, P., Horsley, I., & Docherty, G. (1999). A study of the effectiveness of voice therapy in the treatment of 45 patients with non-organic dysphonia. Journal of Voice, 13, (1), 72-104

Carding, P. (2000). Evaluating voice therapy. Measuring the effectiveness of treatment. London:Whurr.

Carlson, E., & Miller, D. (1998). Aspects of Voice Quality: Display, Measurement and Therapy. International Journal of Language and Communication Disorders, 33, S304-S309.

Colton, R., & Casper, J. (1996). Understanding voice problems. A physiological perspective for diagnosis and treatment. Second Edition

Dejonckere, P.H. (2000). Perceptual and laboratory assessment of dysphonia. Otolaryngologic Clinics of North America, 33, 731-750.

Fex, B., Fex, S., Shiromoto, O., & Hirano, M. (1994). Acoustic analysis of functional dysphonia: Before and after voice therapy (Accent Method). Journal of Voice, Vol. 8, 2, 163-167

Fourcin, A. (2000) Precision Stroboscopy, Voice Quality & Electrolaryngology. In R.D.Kent & M.J.Ball, (Eds.) Voice Quality Measurement. San Diego: Singular Publishing Group

Fourcin, A., McGlashan, J., & Blowes, R. (2002). Measuring voice in the clinic – Laryngograph Speech Studio Analyses. Presented at the 6th Voice Symposium of Australia, Adelaide, Oct. 2002. www.laryngograph.co.uk

Lieberman, J. (2000). Principles and techniques of manual therapy: applications n the management of dysphonia in Harris, T., Harris, S., Rubin, J., Howard, D. (Eds.). The Voice Clinic Handbook. London: Whurr.

Hirano, M. (1981). Clinical Examination of Voice. New York: Springer-Verlag/Wien

Mathieson, L. (1993). Vocal Tract discomfort in hyperfunctional dysphonia. Journal of Voice 2, 40-48: British Voice Association

Mathieson, L. (2001). Greene & Mathieson's The Voice and Its Disorders Sixth Edition. London: Whurr Publishers

Olswang, L.B., (1998). Treatment Efficacy Research in C.M. Frattali (Ed.) Measuring Outcomes in Speech Pathology. New York: Thieme Medical Publishers.

Pannbacker, M. (1998). Voice Treatment techniques: A review and recommendations for outcome studies. American Journal of Speech-Language Pathology, 7(3)49-63.

Ramig, L.O., & Verdolini, K. (1998). Treatment Efficacy: Voice Disorders. Journal of Speech, Language, and Research. 41, S85-S100

Royal College of Speech and Language Therapists (2005). Clinical Guidelines. Speechmark.

Roy, N., & Leeper, H. A. (1993) Effects of the Manual Laryngeal Musculoskeletal Tension Reduction Technique as a Treatment for Functional Voice Disorders: Perceptual and Acoustic Measures. Journal of Voice 7, (3), 242-249. New York: Raven Press, Ltd.

Roy, N. (1994) Ventricular dysphonia following long-term endotracheal intubation: A case study. Journal of Otolaryngology, 24, (3), 189-193

Roy, N., Ford, C., & Bless, D. (1996) Muscle Tension Dysphonia and Spasmodic Dysphonia: The role of Manual Laryngeal Tension Reduction in Diagnosis and Management. Journal of Voice, 851-856

Roy, N., Bless, D., Heisey, D., & Ford, C. (1997). Manual Circumlaryngeal therapy for Functional Dysphonia: An Evaluation of Short- and Long- Term Treatment Outcomes. Journal of Voice, 11 (3):321-331.

Roy, N., & Hendarto, H. (2005). Revisiting the Pitch Controversy: Changes in Speaking Fundamental Frequency (SFF) After Management of Functional Dysphonia. Journal of Voice, 19 (4) 582-591.

Van Lierde, K.M., De Ley, S., Clement, G., De Bodt, M., & Van Cauwenberge, P. (2004). Outcome of Laryngeal Manual Therapy in Four Dutch Adults with persistent Moderate to severe vocal hyperfunction: A Pilot Study: Journal of Voice, 18, (4) 467-474

Websites

www.nhsdirect.nhs.uk

www.laryngograph.co.uk

Appendices

I. Aronson's procedure for laryngeal manual therapy as 1990

II. Mathieson's procedure for laryngeal manual therapy 2001

III. Arthur the Rat

IV. Laryngograph parameters

V. Laryngograph cross-plots for normal voice

VI. Results for subject LM04

Appendix I: Aronson's procedure for laryngeal manual therapy (1990)

Table 1: Procedure for laryngeal manual therapy taken from Aronson 1990 p.314
1. Encircle the hyoid bone with the thumb and middle finger, working them posteriorly until the tips of the major horns are felt. 2. Exert light pressure with the fingers in a circular motion over the tips of the hyoid bone and ask if the patient feels pain, not just pressure. It is important to watch facial expression for signs of discomfort or pain. 3. Repeat this procedure with the fingers in the thyrohyoid space, beginning from the thyroid notch and working posteriorly. 4. Find the posterior borders of the thyroid cartilage just medial to the sternocleidomastoid muscles and repeat the procedure. 5. With the fingers over the superior borders of the thyroid cartilage, begin to work the larynx gently downward, also moving it laterally at times. One should check for a lower laryngeal position by estimating the increased size of the thyrohyoid space. 6. Ask the patient to prolong vowels during these procedures, noting changes in quality or pitch. Clearer voice quality and lower pitch indicate relief of tension. Because these procedures are fatiguing, rest periods should be provided. 7. Once a voice change has taken place, the patient should be allowed to experiment with the voice, repeating vowels, words, and sentences.

Reference:

Aronson,A,E. (1990). <u>Clinical voice disorders, 3rd Edition</u>. New York: Thieme Stratton

Appendix II: Mathieson's procedure for laryngeal manual therapy (2001)

Mathieson (2001) describes Aronson's protocol for manual therapy. In addition, she describes an alternative method:

Table 2: Alternative procedure to manual therapy taken from Mathieson, 2001 p. 499

1. The process is described to the patient and the patient's permission is sought before starting manual therapy.
2. The voice pathologist stands behind the patient who is seated in an upright chair with a low back.
3. The fingers of both hands are placed on the mastoid process behind each ear and the attachment of the sternocleidomastoid muscle is located. The finger-tips are rotated in a massaging movement over the upper part of this muscle, and this movement is continued as they slowly descend along its length. Initially, only very gentle pressure must be used on this tense, tender musculature. Care must be taken when massaging the lower third of the sternocleidomastoids because coughing may be caused in the tense patient. The length of time spent on massaging the sternocleidomastoids varies from one patient to another, according to the degree of tension. As tension reduces, the muscles are noticeably softer and greater pressure can be applied without causing the patient any discomfort.
4. The supralaryngeal area can then be gently kneaded with the finger tips. At first this may be hard and unyielding. The patient should be asked ot relax the mandible and allow the tongue to lie in the floor of the mouth. (The habitual tongue posture in many patients with muscle tension dysphonia (MTD) is for it to be pressed upwards onto the hard palate.)
5. The finger-tips then move in a circular motion over the hyoid bone. This area may be exquisitely tender and should be approached gently.
6. When the sternocleidomastoid muscles and the supralaryngeal area have relaxed, the larynx can be moved with lateral digital pressure.
7. Finally, the patient is asked to swallow and then to vocalise.

Reference:
Mathieson, L. (2001). Greene & Mathieson's The Voice and Its Disorders Sixth Edition. London: Whurr Publishers

Appendix III: Arthur the Rat

There was once a young rat named Arthur, who would never take the trouble to make up his mind. Whenever his friends asked him if he would like to go out with them, he would only answer, "I don't know". He wouldn't say "yes" and he wouldn't say "no" either. He could never learn to make a choice.

Her aunt Helen said to him, "no-one will ever care for you if you carry on like this. You have no more mind than a blade of grass". Arthur looked wise, but said nothing.

One rainy day the rats heard a great noise in the loft where they lived. The pine rafters were all rotten, and at last one of the joists had given way and fallen to the ground. The walls shook and all the rats' hair stood on end with fear and horror. "This won't do", said the rat who was chief, "I'll send out scouts to search for a new home".

Three hours later the seven scouts came back and said, "We have found a stone house which is just what we wanted. There is room and good food for us all. There is a kindly horse named Nelly, a cow, a calf and a garden with an elm tree. Just then the old rat caught sight of young Arthur. "Are you coming with us?" he asked. "I don't know", Arthur sighed, "the roof may not come down just yet". "Well", said the old rat angrily, "we can't wait all day for you to make up your mind. Right about face! March!" And they went off.

Arthur stood and watched the other rats hurry away. The idea of an immediate decision was too much for him. "I'll go back to my hole or a bit" he said to himself "just to make up my mind".

That night there was a great crash that shook the earth, and down came the whole roof. Next day some men rode up and looked at the ruins. One of them moved a board, and under it they saw a young rat, lying on his side, quite dead, half in and half out of his hole.

Appendix IV: Laryngograph Parameters

The following provides specific information about each parameter taken from the Speech Studio User's Guide (www.laryngograph.com), and will explain why these parameters are useful in measuring physical features of voice for speakers with MTD.

Fx: denotes the frequency value of a single vocal fold cycle, the period of the cycle being measured from point of closure to point of closure.

DFx:

This parameter is being used in the study because looking at the two distributions together on the crossplots allows aspects of voice quality to be immediately viewed; pitch height and range, modal structure, and regularity, and "is especially useful for pathological voice analysis". (Fourcin et al., 2002)

The Fx1 is frequency value of the first vocal cycle and Fx 2 shows the frequency value of the immediately following cycle of the pair. The DFx1&2 plots the occasions when two successive periods have essentially the same value, which would happen frequently in a normal voice. An analysis of the two distributions shows the effect of pitch perturbation.

CFx:

Crossplots of vocal fold period to period variability give an overview of intrinsic structure and provide a base for the measurement of irregularity which takes account of normal intonational variation in the speakers' voice. The figure given related to this crossplot shows period to period irregularity as a percentage and provides a quantitative assessment of pitch variability (Fourcin et al., 2002)

The CFx figure gives period to period irregularity as a percentage (CFx). Within 6% deviation from the crossplot line accounts for normal intonational variation in the speaker's voice, therefore, above 6% can be considered outside of normal limits of regularity of vibration from cycle to cycle. This parameter correlates with pitch perturbation (Fourcin et al., 2002).

Qx :

Qx is a practical measure of closed phase and an indicator of voice quality. This is measured by the ratio of the duration of the Lx waveform at 70% of its peak to peak value to the "period" of each cycle. Breathy voice leads to a value of Qx below normal and pressed voice leads to a value of Qx above normal.

DQx1:

DQx1 is the probability distribution for the closed phase of each vocal fold cycle. The peak of the plot shows the most commonly occurring value (modal value). The plot is ordinarily symmetrical about the modal value with a suitable range.

DQx2:

DQx2 is the second order distribution of closed phase and is an indicator of its regularity – the better the closed phase control the more similar DQx2 will be to DQx1. The two traces are shown together here (DQx1 in red) for easy comparison.

QxFx1&2:

The 'Dynamic Contact' plot, Qx1Fx1, is the first order relation between Qx and Fx i.e. every value of Fx is plotted against the corresponding value of Qx. It shows the range of the speaker's voice with respect to Fx and Qx. A normal voice should use a suitable range of closed phase values across its pitch range.

CQx

CQx is another graphical indicator of loudness irregularity with the added advantage of providing a numerical value for the irregularity. The peak amplitude during each vocal fold cycle is plotted against the peak amplitude during the next cycle. For a normal voice most data points are within the core of the diagonal plot. As irregularity increases, so does the amount of scatter and hence the irregularity score.

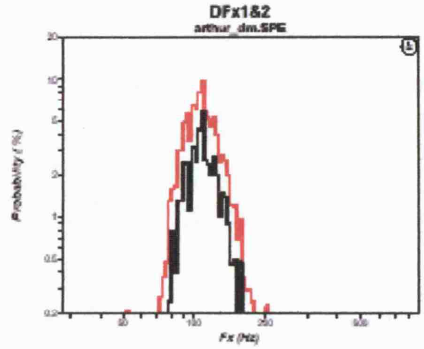
References:

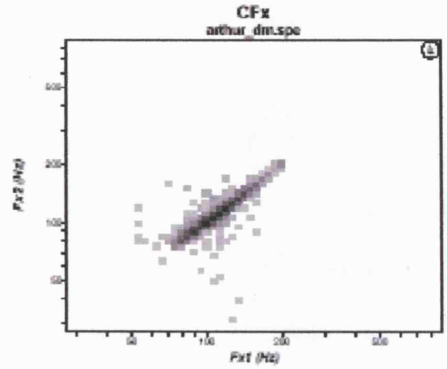
Fourcin, A. (2000) Precision Stroboscopy, Voice Quality & Electrolaryngology. In R.D.Kent & M.J.Ball, (Eds.) Voice Quality Measurement. San Diego: Singular Publishing Group

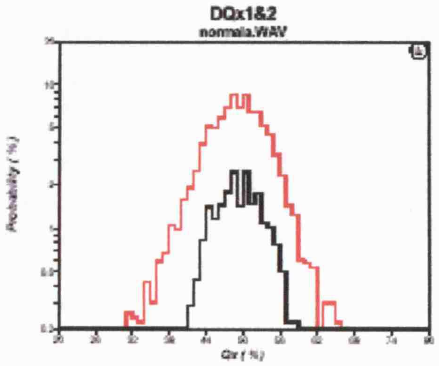
Fourcin, A., McGlashan, J., & Blowes, R. (2002). Measuring voice in the clinic – Laryngograph Speech Studio Analyses. Presented at the 6th Voice Symposium of Australia, Adelaide, Oct. 2002. www.laryngograph.co.uk

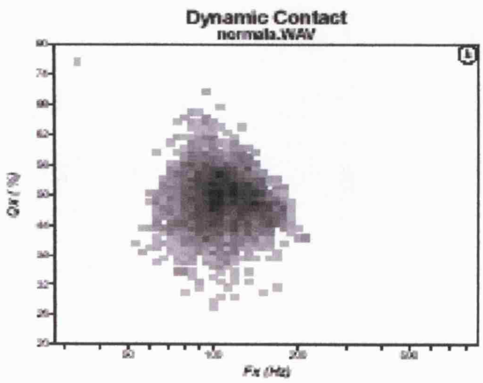
Speech Studio User's Guide, www.laryngograph.co.uk

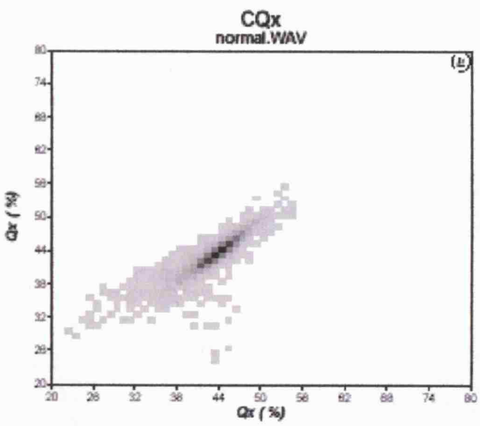
Appendix V: Laryngograph cross-plots for normal voice (taken from the Speech Studio User's Guide.)











References:

Speech Studio User's Guide, www.laryngograph.co.uk

Appendix VI: Results for subject LM04

<u>Inferential statistics for all ten subjects</u> including data for subject LM04

Table 3: Quantitative data from the laryngograph before and after manual therapy for patients with muscle tension dysphonia (including results for subject LM04)

Subject	Gender	Pre-DQx1&2(Hz)	Post-DQx1&2 (Hz)	Pre-CFx %	Post-CFx %	Pre-mean DQx1&2%	Post-mean DQx1&2 %	Pre-CQx %	Post-CQx %
LM01	F	177.15	187.69	8.43	7.27	46.5	45.5	42.78	23.69
LM02	F	187.69	187.69	2.03	[illegible]	46.5	43.5	21.92	69.46
LM03	M	114.87	114.87	13.95	12.14	53.5	54.5	29.27	28.56
LM04	F	172.11	[illegible]	15.22	[illegible]	49.5	59.5	27.59	73.81
LM05	F	210.67	210.67	5.54	10.23	45.5	46.5	5.54	31.63
LM06	F	204.68	216.85	8.09	5.55	43.5	48.5	26.99	20.73
LM07	F	182.34	182.34	8.87	8.36	41.5	46.5	33.9	23.40
LM08	M	136.6	[illegible]	14.84	10.77	47.5	49.5	39.01	34.17
LM09	F	182.34	198.85	13.86	33.41	51.5	53.5	50.85	55.1
(LM10)	F	167.21	172.11	37.72	30.2	52.5	54.5	69.44	65.52
Summary means SD		173.57 (28.99)	177.41 (31.40)	12.86 (9.77)	17.88 (11.78)	47.8 (3.91)	50.20 (5.08)	34.73 (17.34)	42.60 (21.00)

*data in red indicates a change away from numerical values of normal voice **(see appendix x)**

<u>1. Independent variable: Time</u>

Table 4: Effects of treatment over time (including unreliable data for LM04)

	Time pre	SD	Time post	SD	F (1,9)	P
SFo	173.57	(28.99)	177.4130	(31.40)	2.575	0.143
Pitch irregularity	12.855	(9.77)	17.8770	(11.78)	1.902	0.201
Closed phase quotient	47.8	(3.91)	50.2	(5.08)	4.454	0.064
Closed quotient irregularity	34.729	(17.34)	42.607	(21.00)	1.111	0.319

Effects of treatment over time for all parameters were not statistically significant. P>0.05 in all cases.

Appendix VI continued:

2. Independent variable: Gender

Table 5: Means for male and females for each parameter (including data for LM04)

	Males	S.D	Females	S.D
Pre-SFo	125.74	15.37	185.52	15.16
Post-SFo	127.74	18.20	189.83	18.42
Pitch irregularity	14.40	0.63	12.47	11.04
	11.46	0.97	19.48	12.79
Closed phase quotient	50.50	4.24	47.13	3.81
	52.0	3.54	49.75	5.50
Closed quotient irregularity	34.14	6.89	34.88	19.48
	31.37	3.97	45.42	22.80

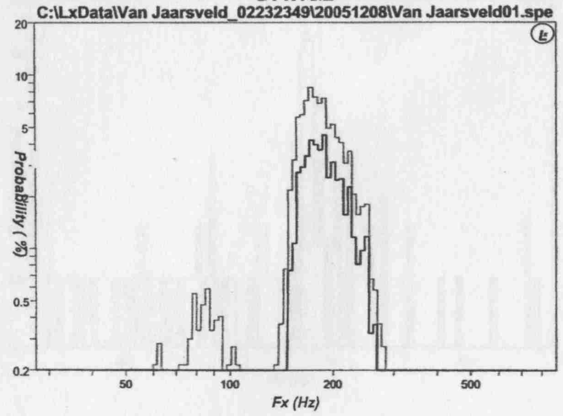
Table 6: Inferential statistics for repeated measures for time and gender (including data for LM04)

	Time		Gender		Time x Gender	
	F (1,9)	P	F (1,9)	P	F (1,9)	P
SFo	1.003	0.346	22.123	0.02	0.133	0.724
Pitch irregularity	0.205	0.663	0.161	0.699	1.225	0.301
Closed phase quotient	1.904	0.205	0.706	0.425	0.142	0.716
Loudness irregularity	0.163	0.697	0.351	0.570	0.478	0.509

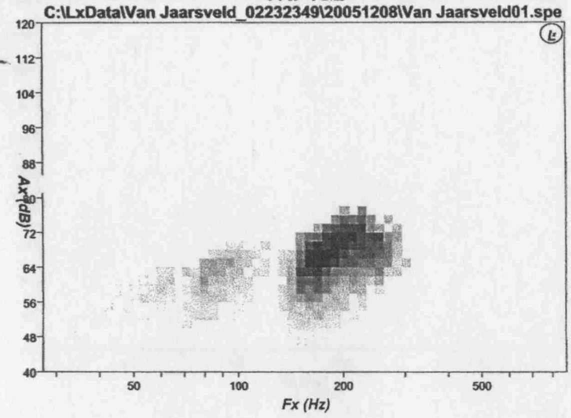
There was an effect of gender for SFo (pitch). P=0.02
There were no significant effects of gender for all other parameters.
There were no significant interaction effects. Gender did not affect treatment.

LM06 PRE

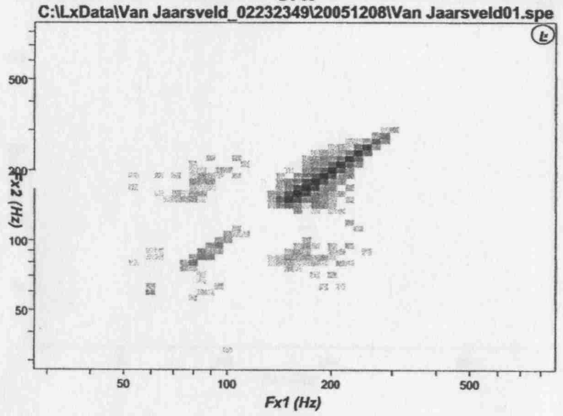
DFx1&2
C:\LxData\Van Jaarsveld_02232349\20051208\Van Jaarsveld01.spe



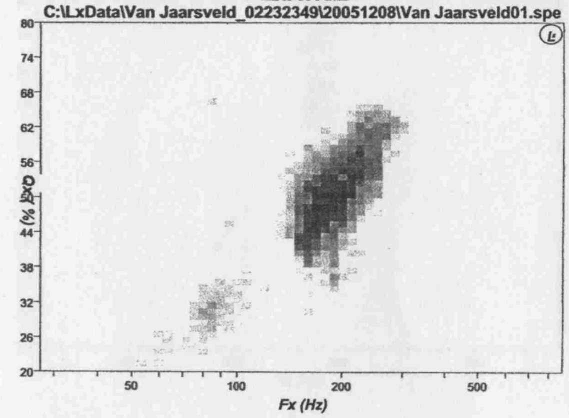
VRP1&2
C:\LxData\Van Jaarsveld_02232349\20051208\Van Jaarsveld01.spe



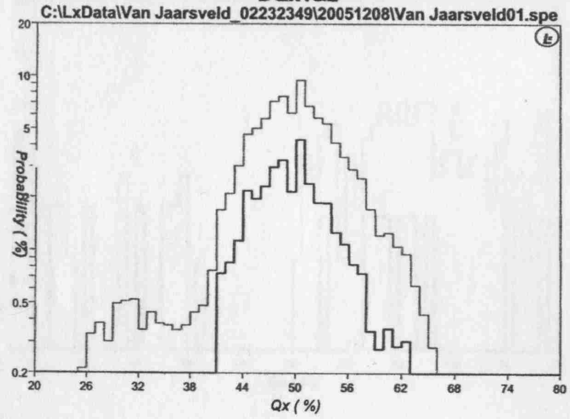
CFx
C:\LxData\Van Jaarsveld_02232349\20051208\Van Jaarsveld01.spe



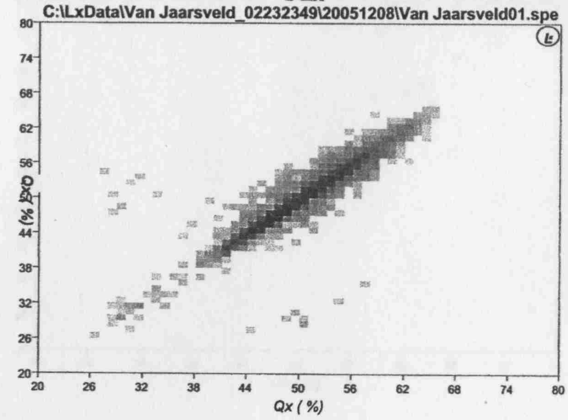
QxFx1&2
C:\LxData\Van Jaarsveld_02232349\20051208\Van Jaarsveld01.spe



DQx1&2
C:\LxData\Van Jaarsveld_02232349\20051208\Van Jaarsveld01.spe



CQx
C:\LxData\Van Jaarsveld_02232349\20051208\Van Jaarsveld01.spe

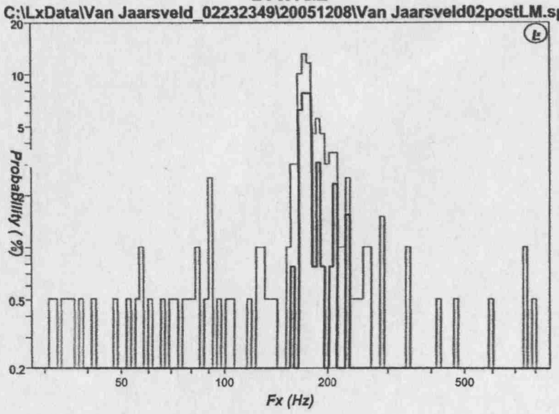


Graph	Samples	< >	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	10262	0, 0	172.11Hz	172.11Hz	179.41Hz	95.81	145.8, 226.1Hz	83.5, 244.5Hz	
VRP1&2	10206	56, 0							
CFx	9808	0, 0							15.22%
QxFx1&2	9889	341, 32							
DQx1&2	9889	341, 32	49.50 %	50.50 %	49.87 %	7.24	42.4, 57.5 %	36.2, 60.5 %	
CQx	9413	46, 36							27.59%

LM06 POST

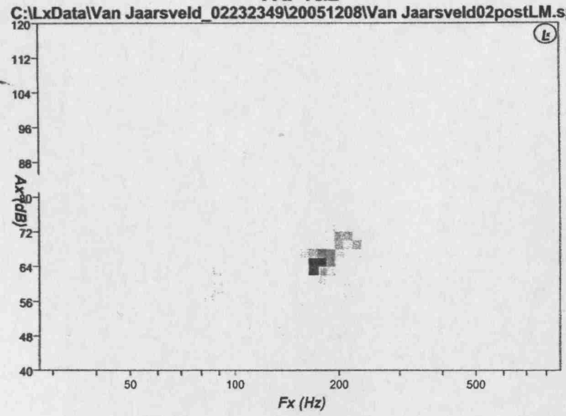
DFx1&2

C:\LxData\Van Jaarsveld_02232349\20051208\Van Jaarsveld02postLM.spe



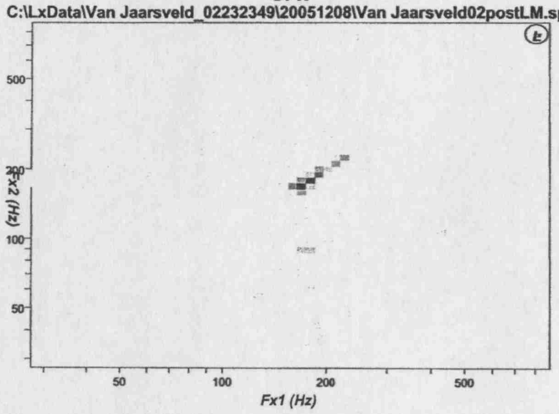
VRP1&2

C:\LxData\Van Jaarsveld_02232349\20051208\Van Jaarsveld02postLM.spe



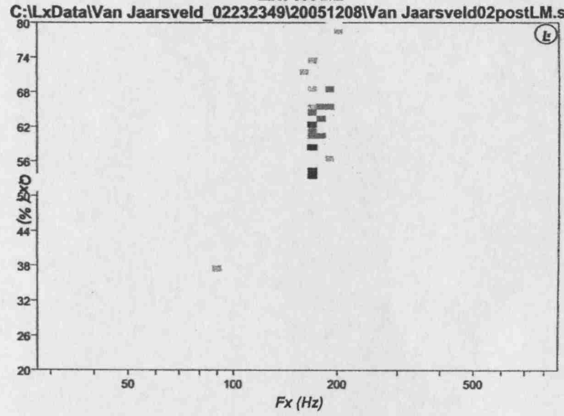
CFx

C:\LxData\Van Jaarsveld_02232349\20051208\Van Jaarsveld02postLM.spe



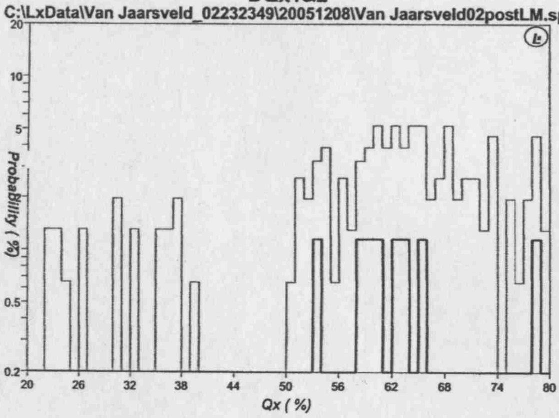
QxFx1&2

C:\LxData\Van Jaarsveld_02232349\20051208\Van Jaarsveld02postLM.spe



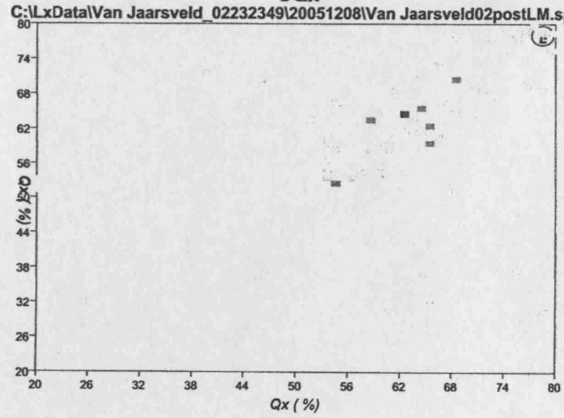
DQx1&2

C:\LxData\Van Jaarsveld_02232349\20051208\Van Jaarsveld02postLM.spe



CQx

C:\LxData\Van Jaarsveld_02232349\20051208\Van Jaarsveld02postLM.spe



Graph	Samples	< >	Mean	Mode	Median	Std. Dev.	80% Range	90% Range	Irreg.
DFx1&2	197	0, 0	162.45Hz	172.11Hz	174.72Hz	154.31	83.2, 230.8Hz	56.4, 288.5Hz	
VRP1&2	193	4, 0							
CFx	128	0, 0							35.16%
QxFx1&2	152	37, 8							
DQx1&2	152	37, 8	59.50 %	60.50 %	62.63 %	13.52	36.6, 75.3 %	30.2, 78.2 %	
CQx	84	1, 7							73.81%